PHASING LOOPS

A Thesis

by

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ABSTRACT

This work consists of a set of eight vector graphics animations exploring phasing loops, intended to be displayed on televisions and monitors, for home use or exhibition in art galleries as Generative Cinema installations. By combining animated loops with different durations it is possible to generate complex images created by simpler basic elements through a phasing effect. After the first loop, the animation gradually desynchronizes. The different combinations resulting from the layering of desynchronized loops generate image variation until the loops return to unison and restart the cycle. The duration of the phasing cycles of six of the eight pieces reach orders of magnitude over 10^{19} frames, which, at a rate of 24 frames per second, is equivalent to the estimated age of the universe (14 billion years). The imagery of the resulting pieces is based on research on properties and structural elements of analog and digital electronic media. This work combines different elements that are present in works from avant-garde movements such as Structural Film, the graphic aspect from Absolute Film, John Cage’s and Andy Warhol’s approaches to the element of time (duration), and the explorations by video artist Nam-June Paik. The generative aspect of this work references minimalist composers and visual artist and composer Brian Eno. This thesis documents the research with analog and digital technologies, and the development of this installation.

DEDICATION

To Tia Lili

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NOMENCLATURE

AVI	audio video interleave (digital video format)
CRT	cathode ray tube
DVD	digital versatile disc (official), digital videodisc (unofficial)
GIF	graphics interchange format
GUI	graphic user interface
h.264	high quality video codec standard with low bitrate, Advanced Video Coding
HD	high definition
LCD	liquid crystal display
LCM	least common multiple
Max/MSP	Max Signal Processing, Miller S. Puckette (software)
MOV	file extension for Quick Time File Format (digital video format)
MPEG2	Moving Picture Experts Group, lossy digital video format
OGG	open multimedia bitstream format, Xiph.Org Foundation
RAM	random-access memory
RGB	red, blue and green
RGBA	red, blue, green and alpha
SWF	Shockwave Flash, multimedia, vector graphics and ActionScript file format

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INTRODUCTION

This work explores the use of loops, that is, the immediate repetition of sequences of images, exactly and without variation, to create a phasing effect, which is the gradual shift out of unison. Phasing loops generate variation through repetition. By combining animated loops with different durations, it is possible to generate complex images created by simpler basic elements. As the piece progresses, these basic elements combine in different clusters and configurations. However, these basic elements never change. Because the variation in the animations is produced by a set of algorithmic rules and processes, this is an example of generative systems applied to the production of cinema.

Another aspect of this work is that because the phasing cycles can be very long, the viewer is not expected to watch the whole piece. The viewer's experience is defined by the selected moments in which one chooses to watch the piece and observe the variation produced by the system. Due to the large number of images generated by the system, the artist cannot know all of the results of the process and becomes himself a viewer of the work. Thus, the outcomes of the process may be as surprising to the artist as to the viewer.

In the first sections of this document, I will present background information defining elements of this work and highlighting artists that have previously used loops, phase shifting, alternative approaches to duration and generative systems in their works.

Next, I describe a series of preliminary studies in which I explored analog and digital technologies, and defined the characteristics to be implemented in the final pieces. I discuss studies made with animation and video, and evaluate the available tools and computer environment suitable for the digital development of the pieces.

Finally, I describe the implementation process and the resulting pieces themselves. These final pieces consist of a set of eight Flash animations intended to be displayed on televisions and monitors, for home use or exhibition in art galleries as Generative Cinema installations.

ARTISTIC INTENT AND MOTIVATION

This work is presented as a Generative Cinema installation exploring the use of loops, that is, the immediate repetition of a sequence of images, exactly and without variation, to create a phasing effect. This will be accomplished by producing vector graphics animation loops. These animation loops are constructed so that each has a different duration. During the execution, after the first loop, the animation gradually desynchronizes. The different combinations resulting of the layering of desynchronized loops generate image variation.

This work constitutes an expressive representation of the elements of analog and digital image formation, to create a visual experience that explores visual perception, including optical illusions. These illusions are a byproduct of the dynamics of color interaction, for example afterimages and simultaneous contrast.

All the pieces start with a black and white image. As the piece progresses, the image starts to disintegrate; after some time, it starts to reintegrate, until it returns to the original state and the process starts again.

The images produced in these phasing loops inhabit a space between figuration and abstraction, and even the more abstract sections of the piece retain traces of the original figure that started the process, in this case a stylized face. The basic elements never change, but create great variety and always reference the first loop, that is, the original animation. At any point in the phase cycle, the viewer should be able to recognize the traces of the face.

The pieces are intended to work both individually and as a group. The group of works can be exhibited in an art gallery where the viewer would be presented with several screens with a different work in each. The viewer would divide his attention between the different works and should be able to recognize their similarities and relationships. In fact, this work is intended to be viewed in a fragmentary way; the viewer is able to revisit a piece and see how it changed from the last time. The extended length of the animation contributes to partial viewing of the work, discouraging the viewer from watching the whole piece, and in this way enabling him to choose the duration of the experience. This makes each viewer's experience unique, constituted by the fragments of cycles one saw.

The extended length of the pieces is a method to inform the viewer that one does not have to worry about missing details, and can feel comfortable to stay and leave in one’s own time. There is no narrative in the traditional, literary sense to demand attention; the viewer is free to make up a story based on interpretation and experience.

The focus of these proposed pieces is placed in the broader context of my work, in which I explore structural elements of analog and digital electronic media (pixels, scan lines, etc.). The imagery exposes, replicates and amplifies the properties and elements of the different video and film display technologies, such as cathode ray tube (CRT) televisions/monitors, LCD screens and projected film. The exploration of old and new technologies was necessary for the understanding of the behavior of different kinds of screens that inspired these pieces.

The loop is something recurrent in my work since 2008 when I made *One Day*, a graphic narrative in woodcut. It consists of 12 stacked paper sheets, intended to be read in a way that after one page is read it is placed on the bottom of the pile. Thus first page can be read as a continuation of the last one, creating a circular narrative, a loop.

In *One Day* (fig. 1), a wordless narrative in woodcut, the imagery is expressionist, and the narrative is constructed by the images without direct transitional elements, inspired by soviet cinema's montage theories, the Kuleshov Experiment and Sergei Eisenstein. Thus, instead of facial expressions, it would be the juxtaposition of the characters' face with another image that would suggest the feelings and thoughts of the character. In this work I also started to explore human-machine relationships.

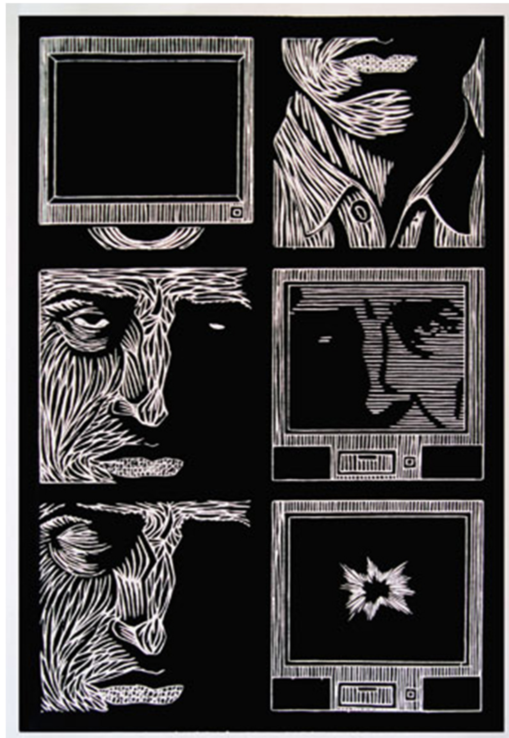

Fig. 1. ***One Day,*** **page 10.**

The recurring image of a geometrically stylized face I am using to create the pieces is reminiscent of a series of works titled *Interface* (2008-present) (fig. 2). *Interface* deals with the relation between humans and the means of image production and reproduction.

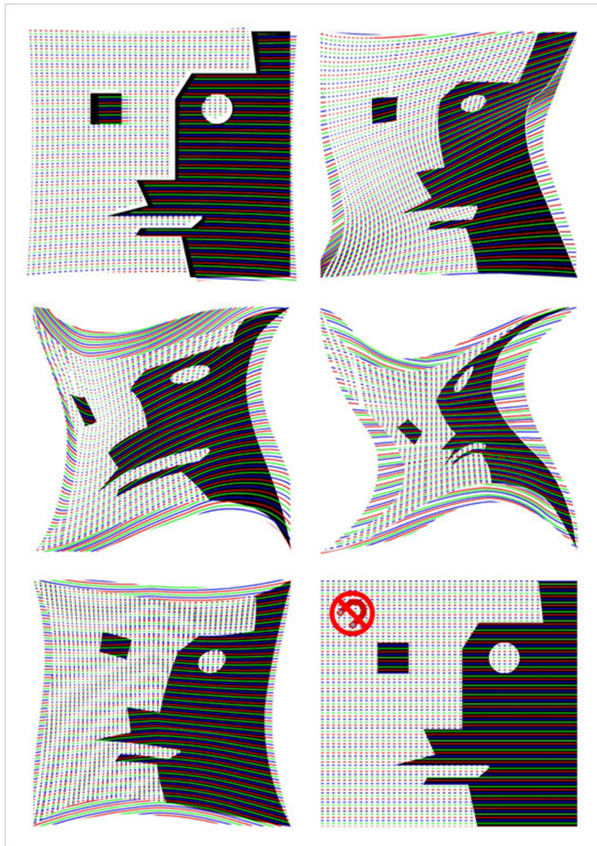

Fig. 2. ***Interface,*** **'Degauss'.**

I have always been interested in the visual properties of particular media and in the textures that result from them. When I began to use the computer as the main tool for drawing, my work slowly became more geometrical and minimal. In *Interface*, facial expressions were replaced by references to analog and digital technologies of image production and reproduction, for example, the face is constructed or deconstructed in a sequence of images with color channels moving in or out of register. In this way the work creates a dialog between machine processes and human processes.

The present research is a logical next step in my work. The pieces in the *Interface* series can be seen as selected frames in a time based piece, arbitrary selections of still frames of the most meaningful moments. In this work with phasing loops I am presenting the whole sequence as it progresses in time, so the viewer, by chance and by choice, is selecting the moments.

BACKGROUND

This work combines several different elements that are present in works from avant-garde movements such as Structural Film, the graphic aspect from Absolute Film, John Cage’s and Andy Warhol’s approaches to the element of time (duration), and the explorations by video artist Nam-June Paik. The generative aspect of this work references minimalist composers and visual artist and composer Brian Eno. In this section, I will provide notes about important elements and about previous works by other artists that contextualize different aspects of the proposed installation.

LOOPS

A loop is the repetition of a sequence of images, without interruption or variation. Loops are elements that were already present in some of the early cinematic experiences, such as the Zoetrope (1834) (fig. 3). A zoetrope is a metal drum that spins, allowing the viewer to see successive images through the slits in the drum. Figures on the strip inside seem to move in a looping fashion. Thomas Edison's 1889 Kinetoscope was a loop-film viewing machine [1] [2]. One of the earliest records of use of the loop as a formal device is Fernand Léger's *Ballet Mécanique* (1924), in which there is a repetition of a woman climbing stairs [3]. Peter Kubelka, who, along with Andy Warhol, is considered a precursor of Structural Film, pioneered the use of several kinds of loops in *Schwechater* (1958). In the 1960's, minimalist composers such as Terry Riley and Steve Reich and structural and avant-garde filmmakers used looping as an expressive resource. The ubiquitous contemporaneous usage of loops is represented in Adobe Flash animation, music sampling, videogames and computer programming. Loops constitute the first central element of this study.

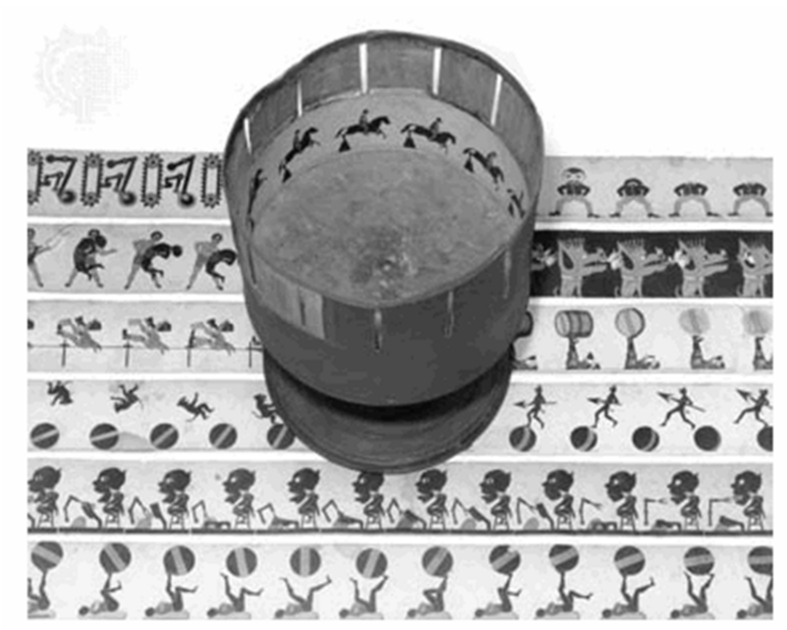

Fig. 3. Zoetrope.

PHASING EFFECT

The phasing effect is the gradual shift out of unison and return to it. In this work, it is used as a generative system. In music composition, “phasing” or “phase shifting” is a technique in which two identical phrases are played simultaneously, but at different *tempos*. This technique was used by minimalist composers such as Steve Reich. I am visually exploring an effect originally described for musical works. This is the second central element of this study.

GENERATIVE ART

Generative Art can be defined as “any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art" [4].

With generative systems, the artist is not a person who finishes pieces of work. Rather, the artist designs a process and sets it in motion, allowing it to progress ideally without human intervention [5]. Due to the large number of images generated by the system, the artist cannot predict all of the results of the process and becomes another viewer of the work. The outcomes of the process can be as surprising to the artist as they are to the viewer.

Generative techniques have been previously used in cinema, such as the case of Karl Sim’s *Primordial Dance* (1991), which uses a genetic algorithm in which the artist’s aesthetic choices act as the selective factor to direct variation [6] [7]. It is also the case of the present work, in which loops and phase-shifting are used to produce the variation observed in each piece.

In this context, this work can be categorized as Generative Cinema, since it uses sets of algorithmic rules (the loop and phase-shifting) as a compositional method to produce the sequences of images that create the illusion of motion.

CINEMA

Opposing Sergei Eisentein's theory that the fundamental aspect of cinema is montage, the filmmaker Andrei Tarkovsky denies drama, narrative and editing as fundamental aspects of cinema, and states that the fundamental aspect of cinema is the pressure of time within a shot: “The dominant, all-powerful factor of the film image is rhythm, expressing the course of time in the frame (…) One cannot conceive of a cinematic work with no sense of time passing through the shot, but one can easily imagine a film with no actors, music decór or even editing.” [8]

Avant-garde filmmakers attempted to identify the fundamental elements of cinema as an important part of their work. For Michael Snow, the essence is “shaping light and shaping time” [9], or, in the words of Stan Brakhage, “the movement of light" [10]; according to Maya Deren, “.[cinema], though composed of spatial images, is primarily a time form" [11]; and according to Moholy-Nagy, "light-space-time continuity in the synthesis of motion" [12]. William Wees emphasized the parallelism between cinema and the sense of vision by recalling that visual perception relies on light fluxes that reach the retina, and thus summarized these concepts in his definition, that is, “light moving in time …the common ground of vision and film" [13]. Thus, there are three interrelated basic principles of cinema: light, movement, and time.

ABSOLUTE FILM

Absolute Film was one of the earliest abstract film movements, and took place in Germany during the 1920s. Walter Ruttman's film *Lichtspiel Opus I* (1921) premiere in Frankfurt, on April 21, 1921, is considered to be the first exhibition of an abstract animated film to a general audience in the world [14]. Other works Walter Ruttmann's *Opus* (1921-1925) (fig. 4), Hans Richter's *Rhythmus 21* (fig. 5), *Rhythmus 23* and *Rhythmus 25* (1921, 1923, 1925), Viking Eggeling's *Symphonie Diagonale* (1925) (fig. 6) and Oskar Fischinger's *Optical Poem* (1937).

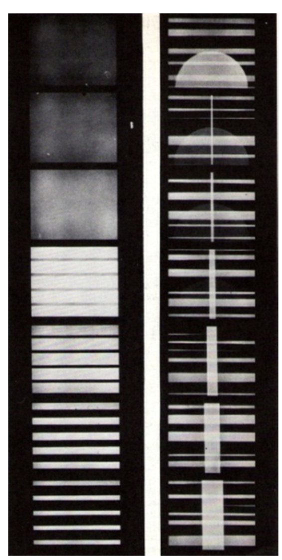

Fig. 4. Sequence from Walter Ruttmann, *Opus IV* [14].

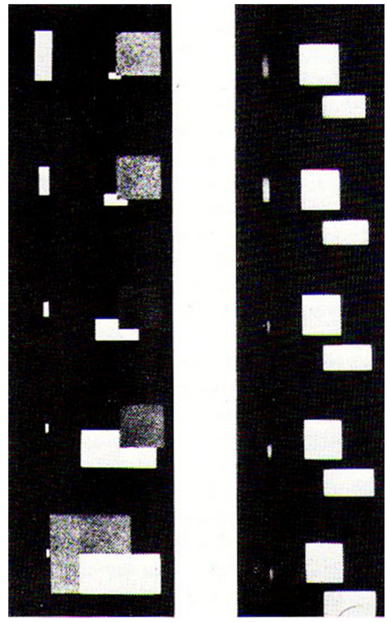

Fig. 5. Sequence from Hans Richter's *Rhythmus 21* [14].

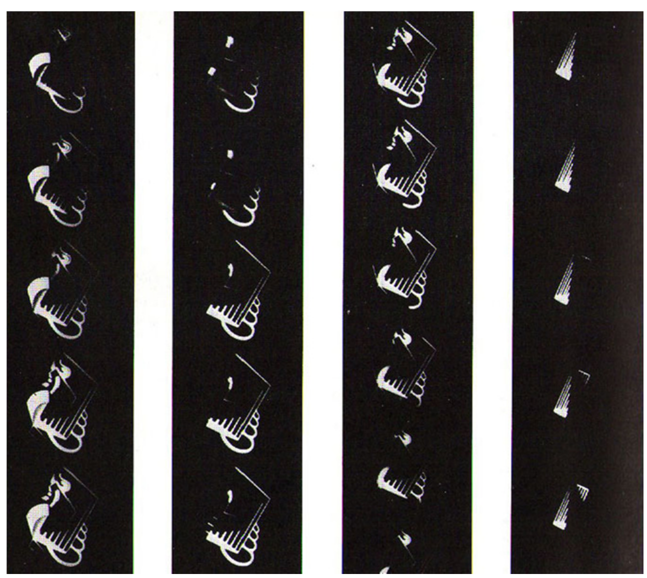

Fig. 6. Sequence from Viking Eggeling's *Symphonie Diagonale* [14].

Two important characteristics of this movement are the graphic use of geometric shapes, and the idea that film can be experienced in an abstract way, like music. In fact, Ruttman's work was reviewed at the time as "a new art form, the vision-music of film" [15]. The Absolute film group's work dealt with perceptual illusions and focused the viewer's attention on shape, motion, rhythm, contrast, and color [16]. These artists explored mathematical concepts to create some of their films, from multiplication and division to geometric permutations [17].

DURATION

The relation between the duration of the work and the duration of the experience of the viewer/listener is an important aspect of this work. The cases in which the artist intentionally produces the work so that these two kinds of duration do not coincide are still rather unorthodox. John Cage and Andy Warhol have produced works in music and cinema, respectively, which illustrate this approach.

In 1963, the musician and composer John Cage directed a performance of Erik Satie's *Vexations* at the Pocket Theater, in Manhattan, with ten pianists playing in relay. The duration of the performance was 18 hours and 40 minutes, the 180 notes of this 80-second work were played 840 times. Cage recognized that Satie's music was defined by means of time lengths instead of structured by means of harmony. John Cage considers that, among the four characteristics of music (pitch, volume, timbre and duration), duration is the most fundamental, because *silence* is defined only by its duration [18].

John Cale, who was one of the pianists at the performance, remembers in his autobiography that “The admission was $5, but members of the audience got a refund of five cents per twenty minutes, and those who stayed to the bitter end got a 20 cent bonus” [19]. Therefore, one can assume that Cage did not require or expect that the audience would sit through the whole 18 hours and 40 minutes of the performance.

The duration and the repetitive nature of Cage's performance of *Vexations* may have inspired artist Andy Warhol to make fixed-frame films, such as *Sleep* (1963), in which half a dozen shots are seen for over six hours, *Eat* (1963), forty five minutes of artist Robert Indiana eating a mushroom, and *Empire* (1964) (fig. 7), a 485 minute static shot of the Empire State Building from early evening to late at night, filmed in 30 minute takes. *Empire* was shot at 24 frames per second and projected at 16 frames per second, so six hours and 36 minutes of filmed footage would become an eight hours and five minutes long screening. Emphasizing the importance of duration in Warhol's films, Michael O'Pray considers that it was “the most innovative [element] (...), the immense length of the film in relation to its minimal subject-matter. (…) Duration confronts the spectator with film itself as material” [20].

Fig. 7. Andy Warhol's *Empire* [18].

Again, the long duration of the film means the viewer is very unlikely to watch the whole piece. As Warhol's collaborator Gerard Malanga asserts, he "thought of his early films as kind of paintings that move" [21]. With these paintings that move, or paintings in time, a spectator would decide the duration of the viewing as one would do with a painting in a gallery or museum, with the contrast that each spectator would have a different experience of the work.

Michael O'Pray also describes Warhol's preoccupation with cinema as an aesthetic, visual medium rather than an instrument to convey a story: "refusing the drama, the narrative and the semantic constructions of editing, Warhol stresses the photographic aspect of the film" [22]. Warhol's use of the fixed frame is one of two major inspirations of the structuralists [23]. He also used loop printing, a characteristic of

Structural Film, in *Sleep*. The other major inspiration to structuralists are works by Kubelka.

STRUCTURAL CINEMA AND BRITISH AVANT-GARDE-FILM

Adams Sitney defines Structural Cinema from the 1960s in terms of four characteristics: the flicker effect, the loop, the fixed camera position, and rephotography of the screen [24].

Beside Andy Warhol, the filmmaker Peter Kubelka is considered the second forefather of structural film because of his pioneering use of several kinds of loops in *Schwechater* (1958) and the production of the first flicker film, *Arnulf Rainer*, in 1960.

Tony Conrad's film *The Flicker* (1965) (fig. 8) consists exclusively of black and white frames, producing a stroboscopic pattern. Conrad describes this film as a way to apply “harmonic structure to light (...) modulating its intensity with time” [25], drawing a parallel between stroboscopic effects and music, by associating flickering frequencies with note frequencies and intervals. Conrad also studied the physiology of the visual perception of flickering and intentionally used flicker frequencies varying mainly between 6 and 16 flashes per second with the goal of producing retinal after-images. He mentions the prolonged exposure to *The Flicker* can induce “a hypnotic state” and even photo-sensitive epilepsy [26] [27].

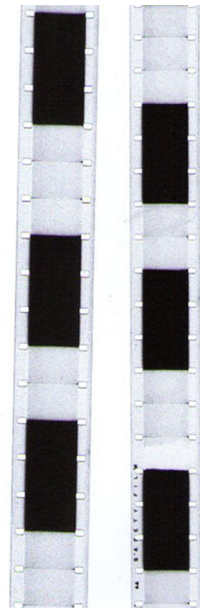

Fig. 8. Sequence from Tony Conrad's film *The Flicker* [30].

Paul Sharits also explored the flicker effect in many of his works, exploring the frame as unit and relying on arithmetic systems to compose flickering patterns [28]. His first film using flicker, *Ray Gun Virus* (1966), consists of alternated flickering color frames of red, black and green to produce rhythmic patterns that induce sensory impressions. In 2011 I viewed a projection of *Ray Gun Virus* at the Museum of Modern Art in New York. The interesting thing I observed is how the flickering patterns form after-images suggesting different colors and even volume through flat colors which are not there. As Stan Brakhage noted for *N:O:T:H:I:N:G* (1968) (fig. 9), "the screen (...) seems to assume a spherical shape, at times" [29]. *N:O:T:H:I:N:G* uses flickering color frames and images. Sharits described *N:O:T:H:I:N:G* as an attempt to visualize the auditory effect of the sound *om*, and in that way, it would not "... 'mean' something – it will ‘mean,’ in a concrete way, nothing”. He explicitly writes about the induced effect of the flicker as “virtual shapes... created by rapid alternations of blank color frames” [30].

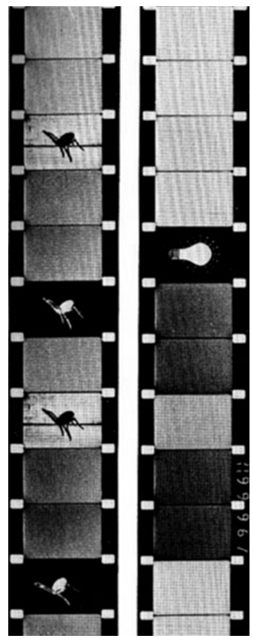

Fig. 9. Filmstrip of Paul Sharits’ *N:O:T:H:I:N:G* [30].

For both, Conrad and Sharits, the optical illusion/after-image/physiological consequence of the flicker is the purpose of the work: the intention *is* to induce the “virtual shapes”. In my work, such effects are not central to the pieces, but can be a consequence adding to their visual complexity.

Sharits used phasing loops of film in *Shutter Interface* (1975) (fig. 10), where he uses four film projectors; each emitting a different color. Every other frame of the films is black, creating color combinations and flicker. According to the description he provides in his notes [31], the projectors "naturally run at slightly different speeds, so they phase in and out of polar relation", resembling the system used by Steve Reich in *It's Gonna Rain*, as described below. In the final form of the work, however, he used four film loops with different lengths [32]. One can assume that in this way, Sharits had better control of the desired phase shifting. I am using a similar system, varying the duration of the loops in my own pieces.

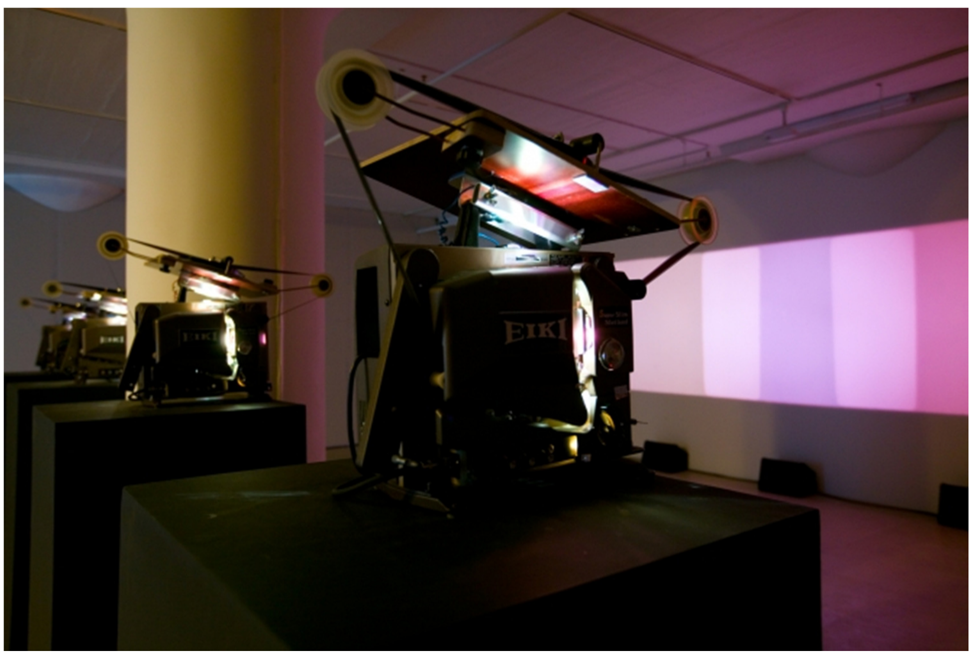

Fig. 10. Paul Sharits' *Shutter Interface* (Source: Smithsonian).

Malcom Le Grice, in his article *Toughts on Recent 'Underground' Film* (1972), expands Sitney's scope of Structural Filmmaking and argues that there were British filmmakers who were operating with similar concerns at the time, and could be considered structural filmmakers. He enumerated eight characteristics common to American Structural film and British avant-garde film, such as the "concern which derives from the mechanism of the eye and particularities of perception" and the "concern with duration as a concrete dimension" [33].

Phasing loops were explored by British avant-garde filmmakers Malcom Le Grice (*Little Dog For Roger*, 1967) and Guy Sherwin (*At the Academy*, 1974) (fig. 11), using different techniques. The work by Le Grice, similarly to Sharits's, used multiple projectors to generate phasing loops, whereas Sherwin's phasing process was created by the physical superimposition, exposure and development of film strips.

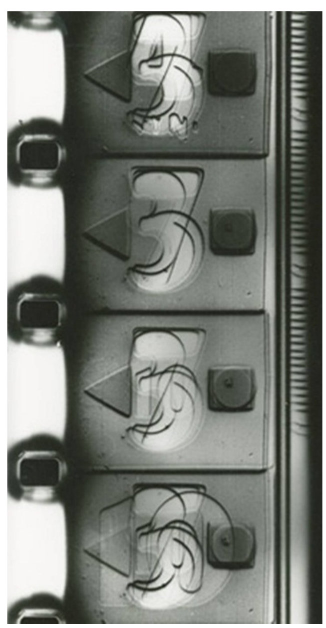

Fig. 11. Sequence from Guy Sherwin, *At the Academy*.

Among contemporary British filmmakers, Simon Payne has also explored elements of structural cinema and phasing loops in works such as *Colour Bars* (2004) and *Primary Phases* (2006) (fig. 12), a two-channel video installation.

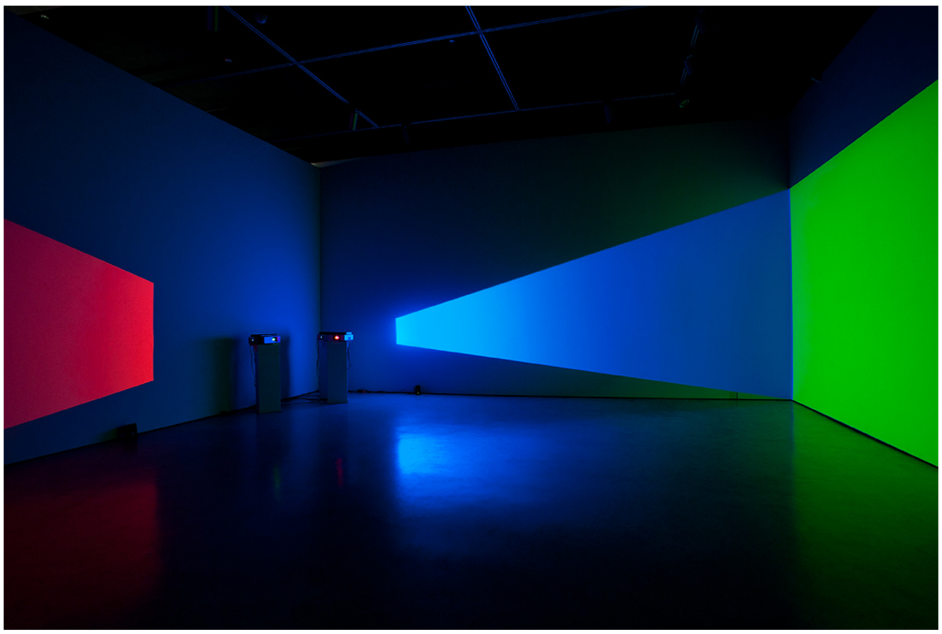

Fig. 12. Simon Payne, *Primary Phases.*

MINIMAL MUSIC

During the 1960s minimalism in music explored different approaches to composition. Among its characteristics are the use of repetition, loops, short patterns, and process. The use of process can produce pieces of extended duration, greater that the original source material used to create the piece, as in Terry Riley's *In C* and Steve Reich's *It's gonna rain.*

Terry Riley

Terry Riley's *In C* (1964) is a piece performed by any number of musicians, who play instruments capable of meeting the requirements of the specified range, about an octave and a half from middle C and up [34]. The piece consists of 53 simple patterns (phrases), lasting from half a beat to 32 beats; each phrase may be repeated an arbitrary number of times. The instructions to the musicians are "proceed through those bars at any speed you choose". Because each musician is playing at his own speed, the duration of the piece varies [35]. Thus, every performance is different and the duration of the whole work is unpredictable, dependent on the dynamics of each group of performers. The result is that this system creates a very complex work from simple elements.

Steve Reich

Steve Reich is an important reference for my work because of his use of phase-shifting as a composing technique in his tape pieces *It's gonna rain* (1965) and *Come Out* (1966). His piece *It's gonna rain* (1965) consists of two identical copies of a fragment of a sermon given by street-preacher saying "It's gonna rain", played by two reel-to-reel tape machines [36]. The two tape loops begin in unison, but gradually go out of synchrony due to the inconsistency of the playback speed of the two machines.

In *Pendulum Music* (1968), Reich explores phasing feedback. Multiple microphones are suspended from the ceiling by cables, each plugged into an amplifier, which is connected to a speaker. Each microphone hangs a few inches above its speaker.

The performers then pull the microphones back, and release them all together. The microphones swing in pendular motion and create feedback as they approach the speakers. Small differences in the distances in which each performer placed and released their microphones create phasing feedback tones. The piece ends after all the microphones are at rest and feeding back constantly [37]. The duration of the piece is determined by the duration of a natural process – as long as it takes for the swinging microphones come to rest [38]. Reich also applied the concept of phase shifting to live performance in his works *Piano Phase* (1966-67) and *Violin Phase* (1967). Reich's concept of a simple process that creates constantly changing unpredictable results later inspired Brian Eno to use generative systems as a compositional technique.

NAM-JUNE PAIK

Nam-June Paik participated in the late 1960s Fluxus movement. He was a pioneer in the use of television and video as art, exploring CRT screens to create media sculptures. Martha Rosler illustrates his importance mentioning that he is responsible for "freeing the video from the domination of corporate TV [and allowing] video to go on and do other things" [39]. He first explored image manipulation, for example, in *Magnet TV* (1965) (fig. 13), where he used a magnet placed on top of a television set to alter the electromagnetic flow of electrons, producing image distortion [40]. *TV-Cross* (1966) is considered the first video sculpture with multiple televisions, an approach that culminated when he exhibited 1003 stacked television monitors for the Olympic Games in Seoul (*The More The Better,* 1988) (fig. 14) [41].

Fig. 13. Nam-June Paik, *Magnet TV*.

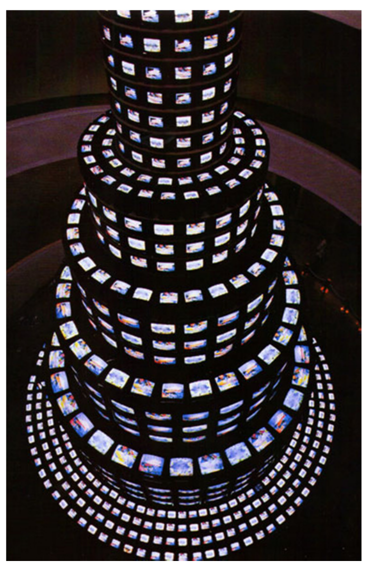

Fig. 14. Nam-June Paik, *The More The Better*.

STEINA AND WOODY VASULKA

Steina and Woody Vasulka, co-founders of The Kitchen electronic media theater in New York, developed a structural approach to video from several influences, including experimental films of the 1920s and 1930s. The Vasulkas are considered pioneers in the manipulation of electronic media and have been involved with video art since the late 1960s [41]. Among their many interests, they explored sound synthesis, stroboscopic light, video, artifacts such as image interference ("electronic snow") (*Noisefields*, 1974) and various types of equipment. Woody Vasulka's background in engineering also led them to develop tools for image manipulation. Many of their works involve the video signal itself, including several forms of feedback. In *Vocabulary* (1973) (fig. 15), Woody Vasulka used system feedback, that is, a setup in which the electronic signal itself is fed back to the system, rather than the image or sound. In *Vocabulary*, the feedback of a dual colorizer is used to change certain areas of the image, a multikeyer translates the brightness signal to sound, and a scan processor allows raster manipulation.

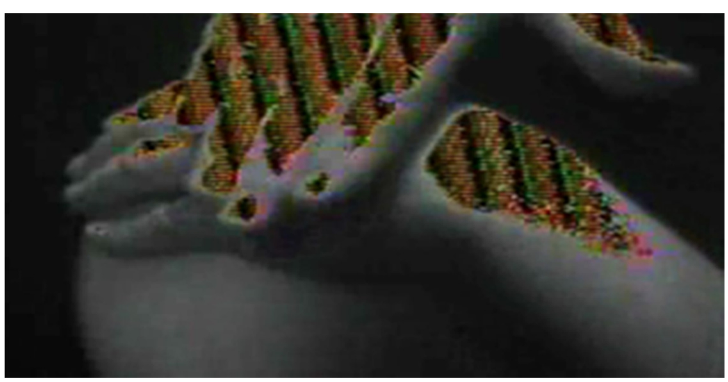

Fig. 15. Woody Vasulka, *Vocabulary*.

BRIAN ENO

Brian Eno is an English musician, composer, record producer, singer, and visual artist. Eno popularized the terms Ambient Music and Generative Music. Having started as a painter, Eno began working with video in the 70's as a "way of making paintings" [42], to explore light as an artist's medium [43]. In this sense, he described TV and video as "a picture medium rather than a narrative medium. Video (…) is a way of configuring light, just as painting is a way of configuring paint." [42]

Eno incorporated variations of Steve Reich's phase shifting technique in many of his musical works with different degrees of manipulation, editing and combining them with other elements. The album *Discreet Music* (1975) and the track "2/1", from the album *Music for Airports* (1978) are clear examples of this technique. Eno continued applying variations of what he called "automatic systems" for composing in his subsequent works *On Land*, *Thursday Afternoon*, and *Neroli*, among others [44].

In 2006, Eno released *77 Million Paintings* as a multiple screen video installation and as a portable video installation, in DVD, for home use. *77 Million Paintings* is a compound video painting, generated by a computer using specially developed software to permute Eno's 296 hand painted images. Four images are overlaid and combined at a time, generating approximately 77 million variations before repetitions begin to happen. The images are chosen at random and slowly fade in and out; the duration of each image is also randomly determined. The speed in which the images fade in and out can be chosen by the user in the DVD version, so that if one chooses a rate of 30 seconds it would take approximately 73 years for all possible combinations to occur [45].

Eno described *77 Million Paintings* as a way to provide something to be shown on TV's and monitors when they would simply sit darkened, and a way to incorporate *time* in a visual arts piece: "Time is the medium we live in… time is… the medium of the composer, but is not usually the medium of the visual artist… what I am trying to do is to take the perceptual frame that you use for music and move it over to the visual arts… so I am trying to make a time based non-narrative visual art." [46]

In 2011 I attended a lecture and exhibition of *77 Million Paintings* during the MoogFest, in Asheville, North Carolina. It was set up using 12 LCD screens, divided into three groups of four, each displaying a different video painting (fig. 16). I visited the exhibition at different times for three days. Two things impressed me: how interesting it is to recognize elements one has seen before in a different combination, and how one focuses on a certain image for some time it does not seem to be changing, but then if one looks away for a moment, it is completely different. Also, the screens were set up in darkened room with comfortable sofas, augmenting the contemplative mood of the installation.

Fig. 16. ***77 Million Paintings*** **during the MoogFest, in Asheville, North Carolina.**

Eno's *77 Million Paintings* (2006) [47] is a fundamental influence for the present research for several reasons. First, it is a system that uses relatively few original images (296) to produce a very large amount of variations (approximately 77 million). Second, the way in which the viewer experiences the work is influenced by the long duration of the piece: the viewer will not see all the 77 million combinations, but will decide when to start and end his experience, and when or if he can revisit the work. Third, because of its portability: the installation was released as a DVD and can be performed in the viewer's home, that is, it works with off-the-shelf equipment.

Brian Eno thinks of his work as a painting – his work changes slowly, almost imperceptibly. I think of my work as cinema because not just light and duration, but also movement is important in it.

PRELIMINARY RESEARCH

The final format of this installation was resolved after creating several studies. I began the research with the intention of using a broad assortment of setups, involving analog and digital cameras, televisions, monitors and projectors. As these studies progressed, I narrowed down the options for the production and display of the phasing loops. However, these studies proved valuable, since I explored characteristics from different technologies (LCD, CRT) and which textures could be obtained. This increased the repertoire of subjects that I would explore in the phasing loops. I compared Adobe Flash, Max/MSP Jitter and Processing in order to identify the best option to produce the phasing loops. I also explored interactivity using Kinect and Max/MSP and the production of optical feedback loops in real time as options to extend the variation of the project.

TECHNICAL CONSIDERATIONS

The proposed work is a collection of pieces that are intended to be displayed on televisions and monitors, and exhibited in art galleries as installations of generative cinema. For gallery exhibitions, the animations are intended to play continuously and uninterrupted for the duration of the exhibition. In order to do so successfully, the implementation format had to meet certain criteria.

The results from the studies were broadly evaluated according to the following guidelines:

- availability of resources: equipment and/or software and cost;
- flexibility: relative to how the resulting work can be exhibited in different contexts, such as an art gallery in comparison to a living room;
- portability: relative to the amount of effort involved in transporting the resulting piece to be exhibited;
- ability to support the reproduction of the complete length of phase cycles: relative to the maximum interval of time during which the setup can display a phase cycle;
- reproducibility of phasing cycles: relative to limits of control the artist can exercise given the technology and equipment;
- amount and complexity of programming required.

STUDIES

Rephotography

The studies were conducted to explore the texture of different monitors. These studies consist of what structural filmmakers called rephotography, in which I would frame the screen or a detail of the screen while it plays a Flash animation.

The digital cameras used were a Canon Vixia HF200 HD and a Canon Rebel T2i. The Canon Vixia HF200 is able to focus very short distances, allowing me to magnify small details of the screen.

Rephotography of the screen was studied as an option with the following configurations:

1. Digital camera capturing a given image from display equipment: a) CRT television (fig. 17), b) LCD television, c) CRT monitor, d) LCD monitor. This approach was used to film both full-screen images and details from the screen.

2. Digital camera framing the viewfinder of a Sony analog camera (AVC-3200 series), which was capturing images as described in item 1. In this process, I was physically manipulating the brightness, contrast, vertical hold (fig. 18) and horizontal hold (fig. 19) through controls in the analog camera. Manipulation of the horizontal hold misaligns the scan lines, whereas manipulation of the vertical hold makes the image roll up and down the screen.

3. Additional studies were made using microscope lenses (fig. 20) and color filter lenses between the camera and the display, and manipulation of the magnetic field of CRT screens to produce color and shape distortion using a degausser (fig. 21) and neodymium magnets (fig. 22). The microscope lenses were attached to the Canon Vixia, allowing a greater magnification and distortion of the images.

4. The formats evaluated to capture the results were digital video (AVI, MOV) and fixed media (DVD).

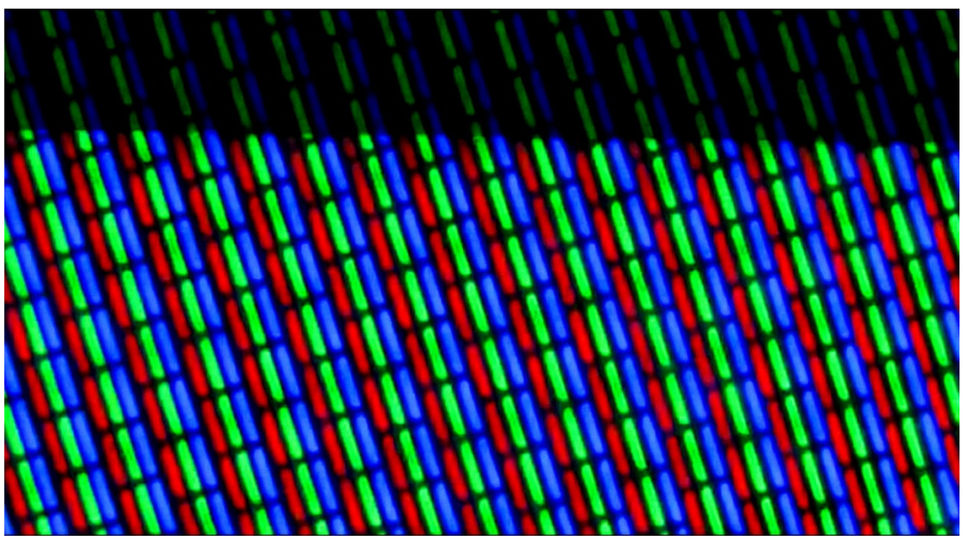

Fig. 17. Digital camera capturing image from a CRT television.

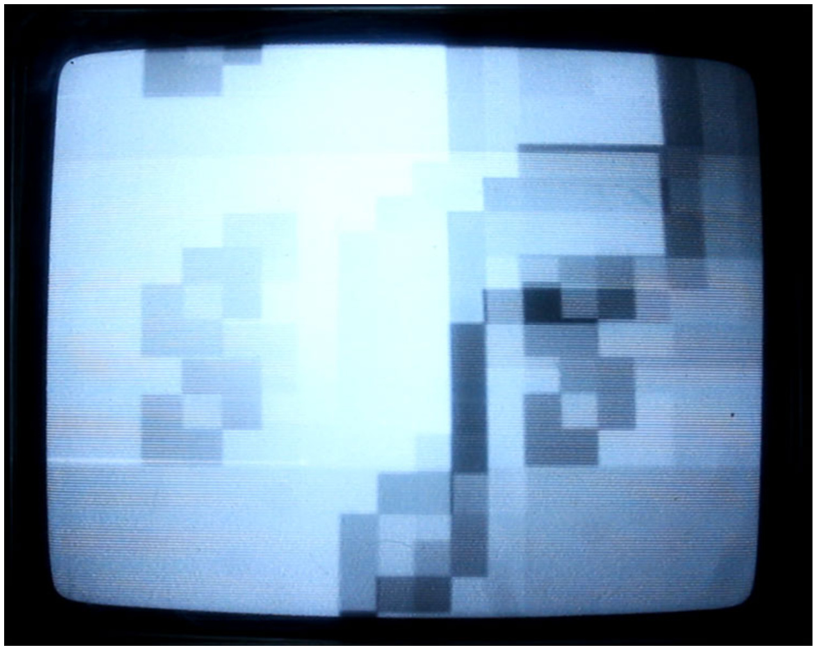

Fig. 18. Digital camera framing the viewfinder of a Sony analog camera (AVC-3200 series), as described in the text, during manipulation of the brightness, contrast and vertical hold.

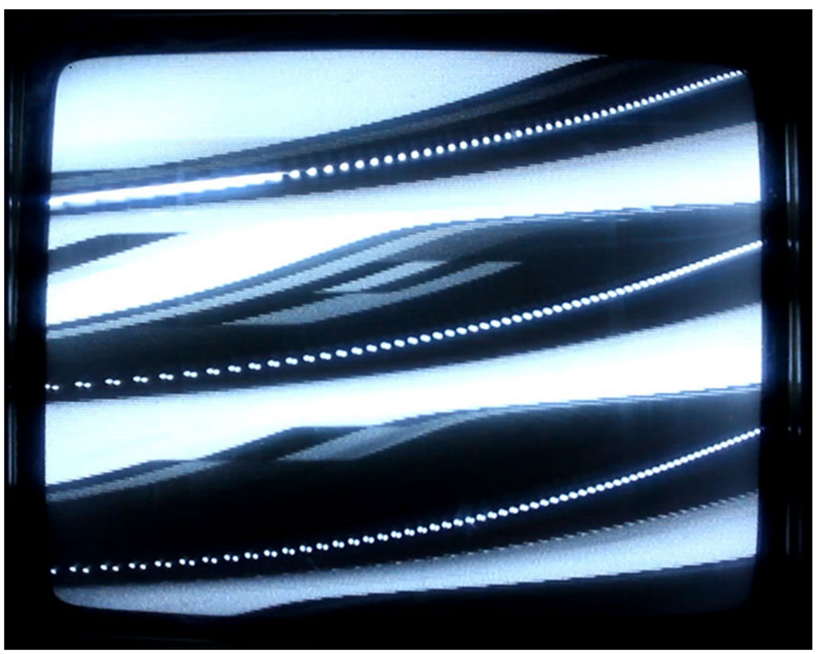

Fig. 19. Digital camera framing the viewfinder of a Sony analog camera (AVC-3200 series), as described in the text, during manipulation of the horizontal hold.

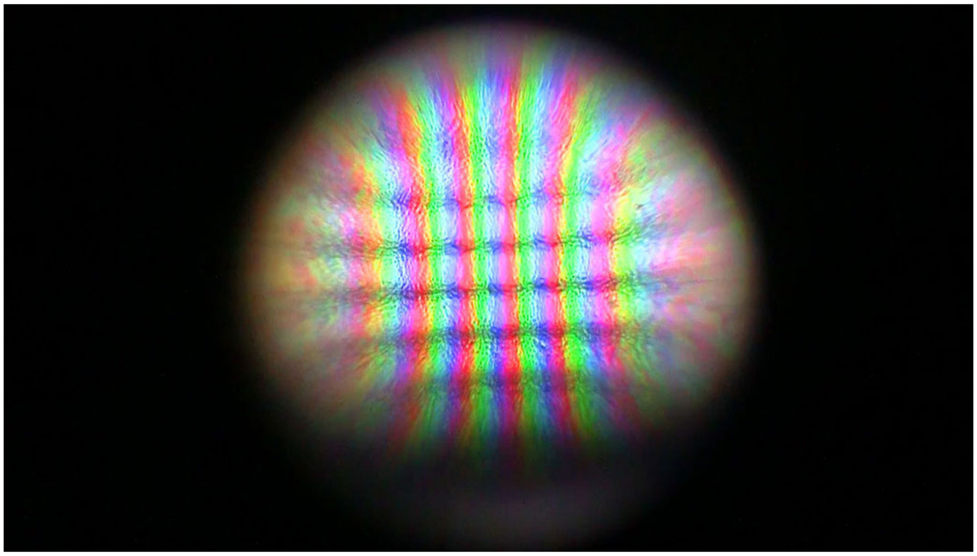

Fig. 20. Digital camera capturing image from a LCD monitor through microscope lens.

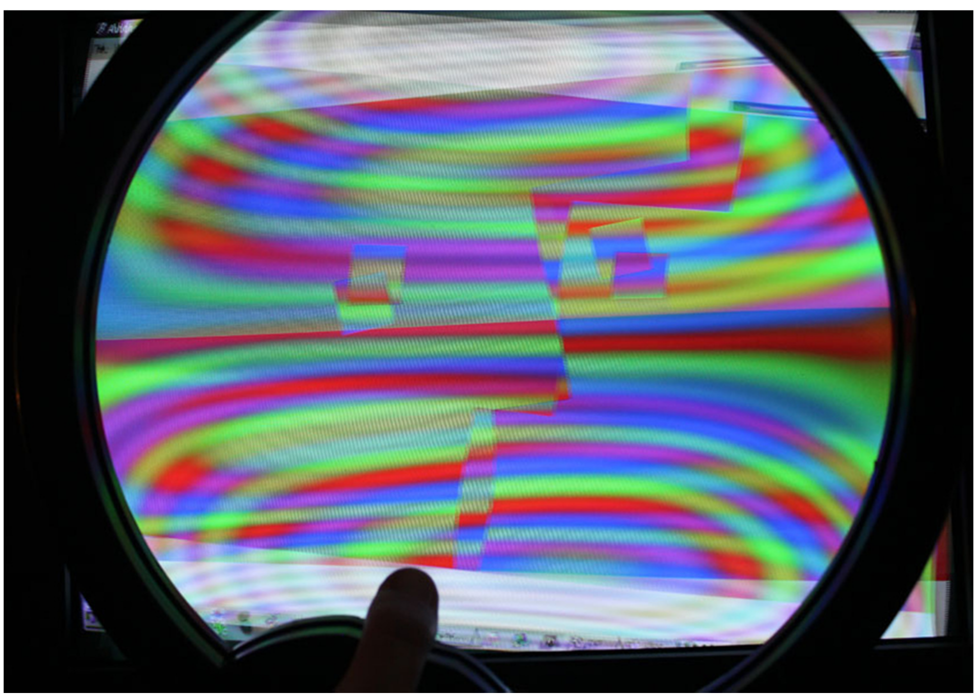

Fig. 21. Digital camera capturing image from a CRT monitor, with color and shape distortion produced by a degausser.

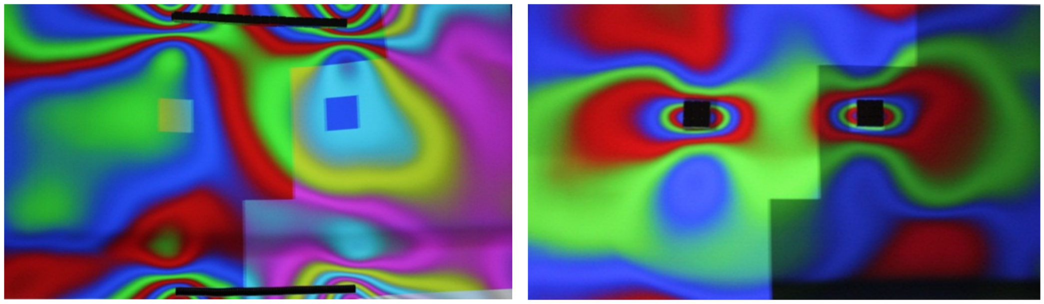

Fig. 22. Digital camera capturing image from a CRT monitor, with color and shape distortion produced by neodymium magnets.

The results of rephotography could be displayed in two manners: either in real time at an exhibition space, or as a fixed media DVD.

This set up proved to be complicated in an exhibition space and not feasible for home use. It is important for this work that the resulting pieces are contained in the two dimensional space of a screen. With these configurations, the result would be more like a sculptural piece in the style of Nam June Paik, instead of the intended 2D display on a screen.

An exhibition would require the availability of several different monitors, televisions and cameras. For each piece, it would be necessary a to include computer and a screen to display the animation, a camera framing part of the animation on the screen and a screen to display the result. Of course if the space permitted, all of this could be hidden from the viewer, and only the final product shown, but this would defeat the purpose of the set up.

Displaying this work as fixed media (DVD, .MOV, .AVI and other digital video formats) would require, first of all, that the process be recorded. There are two ways of obtaining the video: first, by recording the output of the process directly with a video camera, and second, by creating the phasing cycles through a time-intensive editing process, copying and pasting each loop sequence. The production of the video also involves further optimization steps, including determining optimal compression and rendering. Thus, phasing loops displayed through fixed media are not automatic, that is, they are only a record of the process, not the generative process itself.

The greatest limitation for fixed media is time. In the case of the DVD, for example, the piece would have to be up to 120 minutes long, that is, the maximum length of a video that can be recorded on a standard DVD. This could be achieved by limiting the length of the phase cycles, or by recording only a fragment of the cycle. Longer phase cycles could be contained in DVD by compressing the video, with the disadvantage of image quality loss and necessity of experimenting to optimize compression at different framerates. Finally, the limitation also affects storage space: while a Flash animation file with a phase cycle with a potential duration of years is often smaller than 100kb, a DVD requires 4.7GB for 120 minutes of video.

These studies were not used on the final project, but were important observations of the aesthetics and behavior of the technology.

USE OF SOFTWARE / PROGRAMMING ENVIRONMENT

The phasing loops could be obtained through the use of multiple projectors on a single screen, which was often the approach used by structural filmmakers, as discussed previously. The development of digital technology makes it possible to produce phasing loops using a programming environment. In this section, I will provide brief comments about the computing solutions I researched for this installation.

Adobe Flash

Adobe Flash (formerly Macromedia Flash) is a software environment for producing animation and multimedia content, based on vector and raster. It contains a programming language, *ActionScript*, although its interface does not require direct coding. Much of the behavior of the animation can be controlled through the GUI, and it has a built-in vector graphics editor.

The Flash movie native format exported by this program (*.SWF) is different from other common video formats for several reasons. It is optimized for network delivery, on-screen display, extensibility, scalability, speed and scriptability. It allows frame rates from 1 to 60 frames per second and SWF version 10 supports RGBA (the three RGB channels plus transparency) 32-bit graphics [48]. Because it is based on vectors, the image is sharp, clean, and geometric, resulting in a graphic appearance. This characteristic is important for the flexibility of the piece, because the result is also scalable without loss of resolution. The resulting Flash files are also smaller than digital video, which enhances the portability of the work. Another advantage is that, besides the animation, the .SWF format can contain applets for user interactivity.

The loop is the fundamental state of a Flash animation, that is, the author must include a stop code in the last frame in order to prevent the animation from restarting. Also, Flash includes a timeline editor, which organizes and controls a document's content over time in layers and frames [49]. One can also create nested animations, by using the Movie Clip symbol. Movie clips contain individual timelines and multiple layers, which play independently from the main animation timeline [50].

One of the disadvantages of the use of Flash is that it is proprietary software, sold as part of an expensive software suite (Adobe Design Premium CS6, $1,899, as of September 2012). A license for Flash Professional CS6 currently costs $699. The costs are over $400 under institutional agreements. However, the Flash Player application is provided by Adobe free of charge and is compatible with various computer systems and devices.

Max/MSP/Jitter

Max is a programming language for multimedia maintained by the company Cycling '74. It was originally developed in the 1980s [51] as a tool for composing interactive computer music. Because of its modular nature, today it supports a wide range of controllers and devices, allowing their interaction. MSP is a set of audio extensions for Max that allows the manipulation of digital audio in real-time. Jitter is a set of extensions for video that supports real-time video and 3D applications.

The down side of using Max/MSP/Jitter is that the performance drops significantly when one tries to combine numerous independent videos. While Flash can handle up to 16,000 movie clips [52], the amount of information supported by Max/MSP/Jitter is dependent on the computing capacity of the hardware, and on size and resolution of videos.

Max/MSP/Jitter is proprietary software, so there is a cost for the author ($399 for a regular license or $250 for an educational license), although the Max runtime can be downloaded for free.

Processing

Processing, a free and open-source visual programming language, was considered as a possible solution for the construction of phasing loops.

Creating a vector animation in Processing is possible, although programming-intensive: one cannot create objects and simply move them from point A to point B as it done in Flash – the equations would have to be coded. It does support a variety of geometric functions; however, it does not offer a vector graphics editor or a timeline editor. Because of the complex programming requirements, I did not take these experiments further.

INTERACTIVITY AND PHYSICAL COMPUTING

Interactivity and physical computing were considered in the initial phases of this project. In my initial studies I was not exploring phasing loops, but I was using physical computing to allow the audience to interact with Flash animation loops.

A study was made for the classes of Physical Computing (Instructor: Philip Galanter, Department of Visualization Sciences, Texas A&M University) and Music and Sound for Media (Instructor: Prof. Jeff Morris, Department of Performance Studies, Texas A&M University), in collaboration with Computer Sciences major Jon Moeller, using Kinect and Max/MSP/Jitter to track the distance between the viewer and a screen displaying a Flash animation. Each frame of the animation contained an animation loop, and each frame corresponded to a distance between the screen and the viewer. Thus, the the viewer can control the animation by walking forward and backward relative to the screen. This project was presented in Viz-a-Gogo 2010 , the spring exhibition for the Department of Visualization, in downtown Bryan, Texas. Further studies were pursued using Arduino distance sensors, Ultrasonic Range Finder, and a Sharp Infrared sensor.

Another study combined phasing loops and interactivity. The study consisted of three flicker loops, one for each RGB color channel. I programmed a Max/MSP/Jitter patch that would collect and average the color of the pixels in the center of the webcam image and use the average color value of each RGB channel to control the frame rate and transparency of each loop. As a result the average color of the screen was based on the average color (clothes, hair, skin and background) of the person standing in front of it, facilitating identification of the viewer with the stylized face on the screen.

As I discovered phasing loops I abandoned the idea of encouraging the viewer to interact with the piece by moving around the exhibition space. Interactivity changes the way the viewer relates to the piece, often resulting in a playful approach, while my intention is to establish a contemplative approach. Also, allowing the viewer to produce changes would interfere with the flux of the loops. I finally decided that the long duration of the pieces should provide sufficient interactivity, in the sense that the viewer has an individual experience and can choose its duration.

OPTICAL FEEDBACK

By pointing a video camera at its playback video monitor, a feedback loop is created. If the whole monitor is framed by the camera, the effect created is of an endless succession of nested monitors. If a section of the monitor is framed in extreme close up, the feedback creates a loop of changing abstract patterns. Different results can be achieved by varying the cameras, monitors and settings. I have also used luminous objects placed between the camera and the screen to obtain visual effects.

An optical feedback study (fig. 23) was made for the class of Generative Art (Instructor: Philip Galanter, Department of Visualization Sciences, Texas A&M University). The video was created by pointing a Canon Vixia HF200 HD camera at a LED TV displaying the camera's output, shooting flashes at the TV with a still camera and tuning the room lights on and off. The soundtrack was created by manipulation of the audio feedback recorded by the camera.

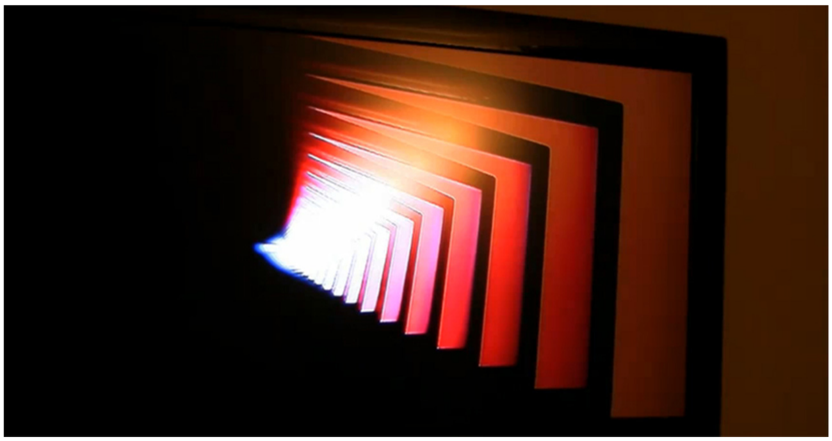

Fig. 23. Image capture of a feedback loop produced by pointing a digital camera at a LCD screen.

I have presented live performances of feedback at the Fallout Theater (Blocker Building, Texas A&M University, 2011), and at the Viz-a-Gogo 2011 exhibition, in collaboration with International Studies major Luis Galindo for the Music and Sound for Media class (Instructor: Prof. Jeff Morris) at the Department of Performance Studies, Texas A&M University.

A solo performance (fig. 24) was presented at the Electric LaTex Music Festival at University of Texas-Austin (November 11-12, 2011) as part of the Electronic Composition class (Instructor: Prof. Jeff Morris).

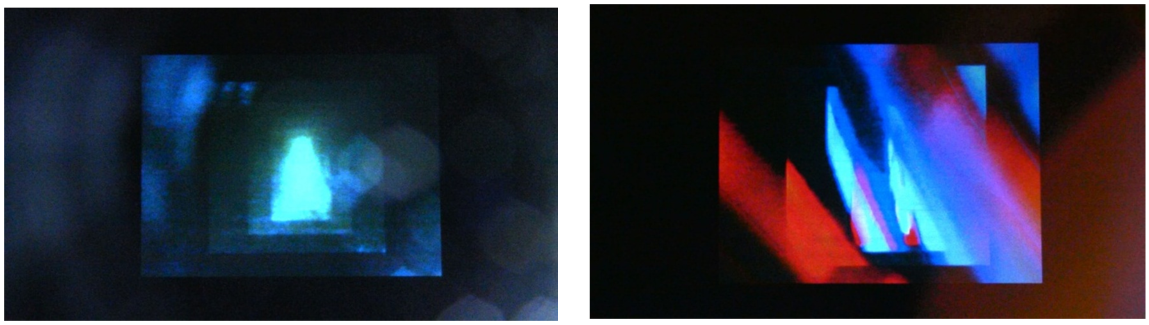

Fig. 24. Stills of the video from the feedback performance at Electric Latex, Austin, November 2011.

CONCLUSION

Based on the criteria of availability, portability, flexibility and adequacy for the construction and display of phasing loops, I concluded that the best option for my work would be to create movie clips in Adobe Flash, followed by their combination to produce a final animation, incorporating phasing loops. Although rephotography methods were not used, they served as inspiration for visual effects to be produced digitally by the phasing loops. I have also decided that the generative system provides sufficient interactivity, in the sense that the viewer has an individual experience and can choose its duration.

IMPLEMENTATION AND RESULTS

IMPLEMENTATION

Computing Requirements

The phasing loops were created on a PC computer with 4GB of RAM, 2.26GHz Quad-Core Intel Xeon processor, Nvidia Quadro 400 graphics card with 512MB buffer, running Adobe Flash CS4 Professional (Adobe Design Premium CS4 suite).

In order to display the pieces, one needs a computer capable of running Adobe Flash Player 11. Adobe recommends minimally a 2.33GHz or faster x86-compatible processor, or Intel® Atom™ 1.6GHz or faster processor for netbooks, a recent browser (Internet Explorer 7.0 or later, Mozilla Firefox 4.0 or later, Google Chrome, Safari 5.0 or later, or Opera 11), 128MB of graphics memory, and 128MB of RAM if the operating system is Windows (XP or later), 256MB for Mac OS (10.6 or later) or 512MB for Linux. The animations are intended to play continuously and uninterrupted during the duration of the exhibition. Therefore, it is necessary that the computer is capable of executing the phasing cycles without crashing.

Display Requirements

These works are meant to be modular and adaptable to the availability of different venues and different screens in the 16 x 9 ratio. They can be displayed in any configuration between 1 and 8 pieces, using plasma, LCD or CRT screens; however, they will be best viewed on screens that support the HD format (frame size 1920 x 1080 pixels).

For gallery exhibition, the optimal presentation is achieved by displaying the pieces in a darkened space, using eight screens of the same size, at least 23 inches, in full HD (16:9 aspect ratio, frame size 1920 x 1080 px), mounted on the wall according to the same practices used for the display of paintings.

CRT TVs and monitors present excellent contrast ratio, color gamut, black level and viewing angle. However, they are also larger, heavier and consume more energy; they are not as common and are no longer produced. Non-flatscreen CRT displays also present geometric distortion and are normally produced in 4:3 aspect ratio, with a few exceptions, which does not match the aspect ratio of the animations, which is 16:9 [53].

LCD screens are preferred because they are cheap, light weight, come in variable sizes, are capable of displaying deep blacks and good color saturation, and present a sharp image when used at native resolution. Unlike CRT screens, LCD screens are not subject to geometric distortion. LCD screens require finer contrast adjustments, and the display of black depends on both the liquid crystal's native contrast ratio as well as the presence of a mechanism of dynamic contrast ratio adjustment [54]. LCD screens also can present a limited viewing angle, that is, the perceived color can vary according to the viewer's position.

Although plasma screens are not excluded and also present excellent color and contrast ratio with no geometric distortion, they tend to be more expensive and fragile. Also, the glass screen can produce glare and reflections.

Projection was discarded as an option because the color black is very important for this work, and a deep black cannot be achieved on a projected screen. Projection is also compromised by light levels in the space. Additionally, more space is required to rear-project the work to avoid viewer obstruction of the projection, which happens with frontal projection.

CONSTRUCTION OF THE PHASING LOOPS

To create the phasing effect an animation is produced at a predetermined duration, for example 24 frames. Each element of the animation is put in a loop, and to each of the loops blank frames are added consecutively: first none, than one, two, three, and so on. At each repetition of the animation loop the images will combine in a different way until they return to unison and the process starts again. In figures 24 to 26, I start with three animation loops of the same duration (3 frames) (fig. 25), then add one blank frame to the second loop and two blank frames to the third (fig. 26), generating a phase cycle with 60 frames of variation (fig. 27).

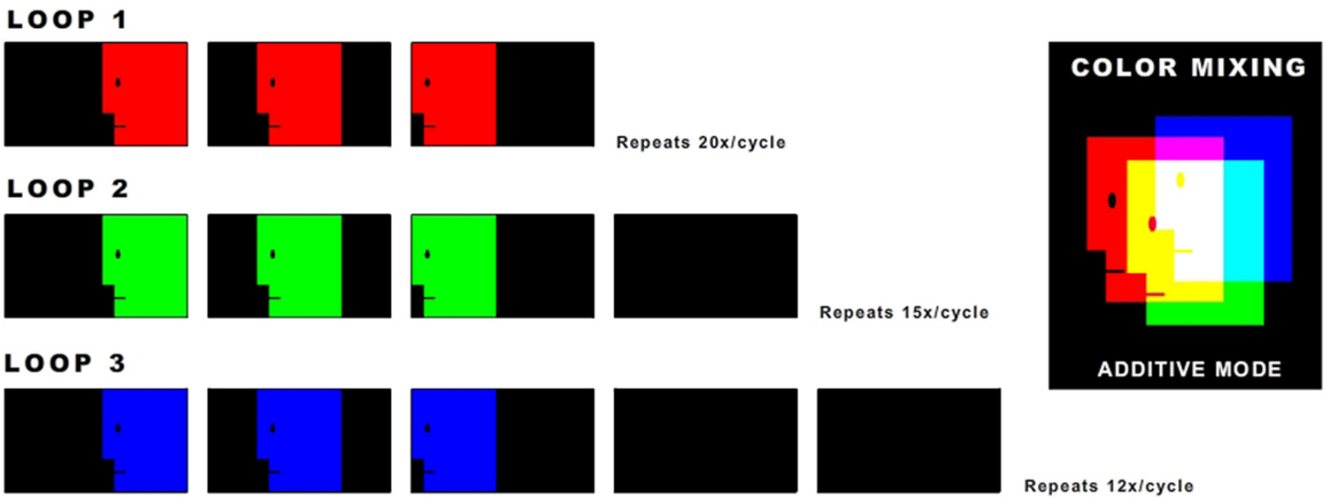

Fig. 25. Three loops, which will combine in the animated sequence (fig. 27). The red, green and blue elements will mix in additive color mode.

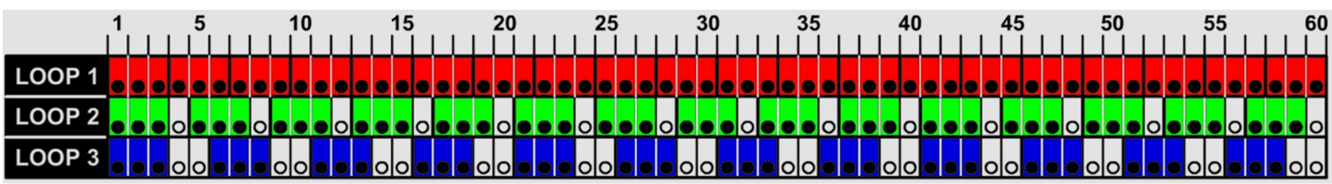

Fig. 26. Animation timeline for the complete phase cycle.

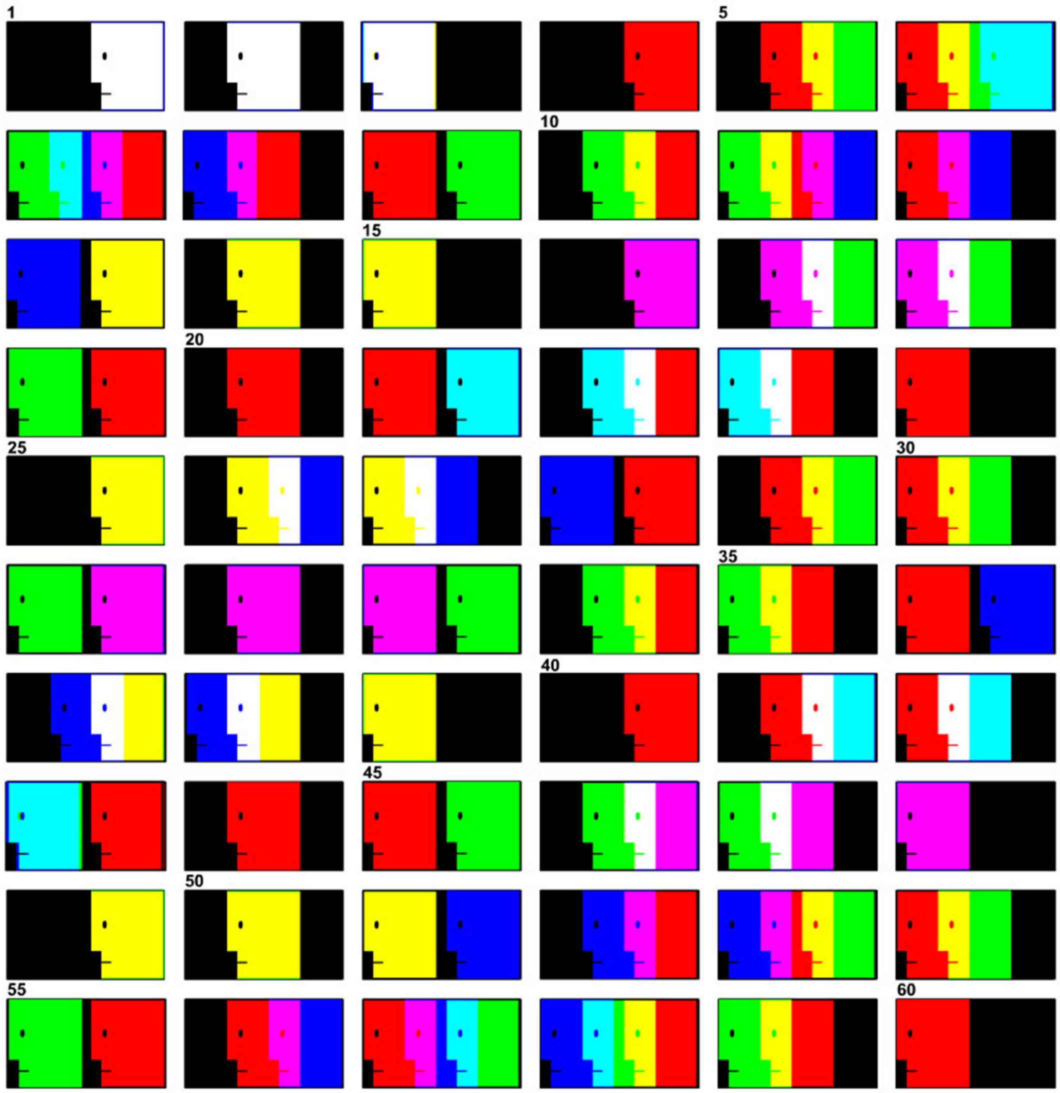

Fig. 27. Animation sequence combining three loops.

To calculate the duration of the animation, I take the number of frames of each loop and calculate the least common multiple. If there are three loops, the first 24 seconds long, the second 25 and the third 26 it would take 7800 frames or, at 24 frames per second, approximately 5 minutes and 41 seconds of variation until the loops return to unison. The loops are created to be seamless, that is, the first frame of the loop is continuous with the last one.

I have identified five types of content loops that can be used individually or in combination with other types. They are: transparency, color, shape, motion, and flicker.

Transparency Loop

The variation of the image is created by figures that appear (fade in and fade out) and disappear seamlessly by animating the transparency of the figures from complete transparency to complete opacity and return to complete transparency, or from complete opacity to complete transparency and return to complete opacity (fig. 28).

Fig. 28. Animation sequence of transparency phasing loops.

Color Loop

To create colors using the whole range of the RGB color spectrum it is necessary to combine three loops: one with a red image, one with green and one with blue. For example, consider that each of the loops goes from complete transparency to complete opacity in 256 frames. By adding one blank frame at the end of the green loop and two blank frames at the end of the blue loop and playing them at 24 frames per second they will go out of phase and create all the colors of the RGB spectrum with some repetition until returning to unison at approximately 98 hours and 23 minutes later (fig. 29).

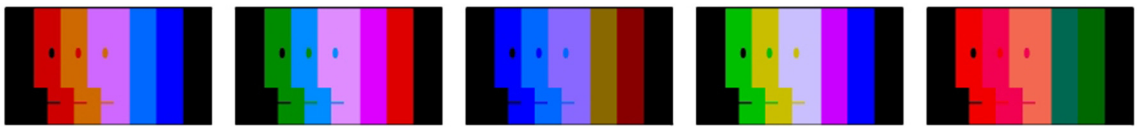

Fig. 29. Animation sequence of color phasing loops.

Shape Transformation Loop

Variation is created by the combination of figures that change shape, for example, an animated loop of a triangle transforming into a circle and then back into a triangle (fig. 30).

Fig. 30. Animation sequence of a shape transformation loop.

Motion Loop

Each motion loop can be an image layer that, when combined with other layers, creates an image that is disassembled and reassembled as the loops go in and out of phase (fig. 31).

Fig. 31. Animation sequence of motion phasing loops. See figure 27 for a complete sequence.

Flicker Loops

In flicker loops (fig. 32), each loop is composed of some blank frames and some frames with figures in a way that, when playing, the figures appear and disappear (flicker). Variation is created by loops with different lengths of blank frames and frames with images, making the figures flicker at different rates. Each flickering image can appear by itself when the other loops are showing blank frames or can create a variety of images when combined with other flickering images.

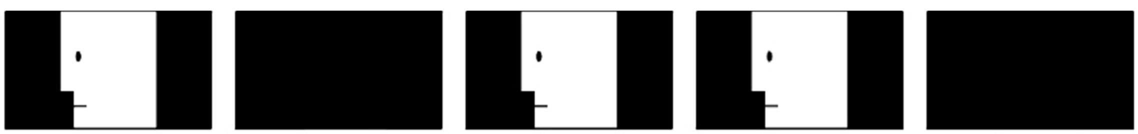

Fig. 32. Animation sequence of a flicker loop.

IMPLEMENTATION ISSUES

The main issue found during the implementation of the phasing loops using Flash is the occurrence of screen tearing, i.e., the display device shows information from two or more frames in a single screen draw [55].

This artifact occurs when the device is not in synchrony with the display's refresh rate. The Flash player frame rate and update is separate from the desktop vertical refresh rate. Therefore, tearing occurs in all movies with motion and flicker, although it is more conspicuous when the movie presents vertically long objects. This problem persists even if the movie frame rate is the same as the screen refresh rate.

This problem was avoided by moving objects at a rate of 1 pixel per frame at 24 fps, so tearing is not perceived.

In the case of flicker animations, tearing was prevented in two ways: first, by having objects with short height. For images with the height of the screen the problem was reduced to an acceptable level by choosing GPU Hardware acceleration in the publishing settings of the final .SWF file. The degree of screen tearing can vary with the hardware, and may not even be apparent in some systems.

Another observation must be noted on the estimate of the duration of the pieces. As explained in the previous sessions, the duration of the piece is defined by the phasing cycle. In order to calculate when the loops will synchronize and start the phasing cycle again, one must take the LCM (least common multiple) of the duration of all loops, in frames. The calculation of the LCM for a small number of loops, for example, 2 or 3, with few frames, can be easily performed. The pieces I created have 6 or more loops, and the number of frames increases in successive numbers. With the increasing number of loops, the calculation becomes impracticable, and the necessary numerical approximations make it impossible to verify the result. For loops with duration in the hundreds of frames, 7 or 8 loops are sufficient to reach a duration close to an order of magnitude of 10^{19} frames, which, at a rate of 24 frames per second, is equivalent to the estimated age of the universe (14 billion years) [56].

PRESERVATION ISSUES

Because the SVG format is proprietary, and associated with Adobe Flash, one can consider that the preservation of the video pieces produced is tied to the availability of software.

Digital video preservation is a debate in its own right. Many libraries have converged on the protocol that video that is purchased as VHS or DVD, should be converted to a preferably lossless digital format for storage on mass storage media (hard drives) [57]. This effort is justified by the fast cycle of deprecation of the media storage formats (diskettes, CD's, laserdisc, DVD's, etc.). However, although there is a consensus about the storage in hard drives, there does not seem to be a consensus about the recommended digital format for archival purposes [58] [59] [60].

Different institutions use formats such as AVI, QuickTime, and lossless JPEG2000. The overall recommendation from the Library of Congress seems to be to store more than one format, and the choice depends on several factors related to the workflow and resources available [61]. Storing multiple formats is also the solution used by the Internet Archive [62] [63].

There have been many criticisms about the preservation of web sites that use Flash [64], but there has not been much discussion about Flash as a moving image file format. The digital preservation guide from the Library of Congress indicates that SWF is a relatively sustainable format [65], in the sense that Adobe disclosed the file format specifications and authorizes its use through a free license [48], so it no longer holds exclusive rights to produce programs that can read and write SWF. However, the SWF file itself is not "transparent", that is, the code is not human-readable and the binary format is proprietary.

The Internet Archive derives the following formats for preservation for a Flash video input: h.264, h.264 720P, MPEG2, OGG Theora, and an animated GIF for display on the entry. However, these formats would fall back on the same problem discussed previously for fixed media – they would preserve maybe one phasing cycle, but the loops would not be interacting in real time when the file is reproduced.

This work is also preserved through the provided documentation, which contains descriptions which would allow the pieces to be reconstructed.

RESULTS

Several studies were made before the central idea of phasing loops was defined. Others explored loops, but not the phasing effect. After this earlier series, I chose fewer pieces with stronger consistency, establishing that the pieces would have to satisfy three conditions: they should present a stylized face, explore the phasing effect, and the first frame and/or the first iteration of the loops must produce a black and white image that progressively creates color variation. Eight pieces that meet these criteria were chosen for representing different aspects of what can be produced with the five types of phasing loops (transparency, color, motion, flicker and shape transformation), individually or in combination.

Eight was initially an arbitrary number since this work can be expanded in the future, but was kept as an ambiguous reference to 8-bit color graphics, the information unit (one byte), and computer architectures.

The pieces *Convergence, V-hold* and *H-hold* explore motion loops. *Scan Lines* explores transparency/color loops. *Ghosting* explores motion and transparency/color loops. *Tune In* uses shape transformation and transparency/color loops. Finally, there are two flicker loop animations, *Bitmap* and *Color Bars*. I provide the duration for three of these loops: *Convergence*, *Bitmap* and *Color Bars*, which were verifiable. For the other loops, the values were above the age of the universe, as explained in the previous section.

All pieces are vector animations with aspect ratio of 16:9, and high definition resolution, 1920 x 1080 pixels, set at 24 frames per second, which is the standard for sound motion pictures established in the 1920s [66]. All the animations begin with a black and white image. This condition can last for one frame of for the complete first iteration. More complex color schemes are formed due to the phasing cycle, in which the layers with different colors combine in different blending modes.

Adobe Flash has 12 color blend modes, which define the blending behavior of pixels in overlapping objects. In these pieces, I use the modes “screen” (fig. 33), “difference” (fig. 34) and “subtract” (fig. 35). The “screen” mode acts as an additive color mode when the background is black, that is, the combination of the R, G, and B channels is white. “Difference” transforms the base color, which is the color underneath the blend color, in its complementary color. In this mode, the combination or R, G and B produces transparency. “Subtract” is the subtractive color mode, in which the combination of C, M and Y produces black, whereas the combination of any two colors in RGB produces black.

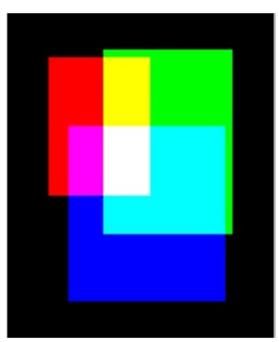

Fig. 33. Illustration of blending modes: screen.

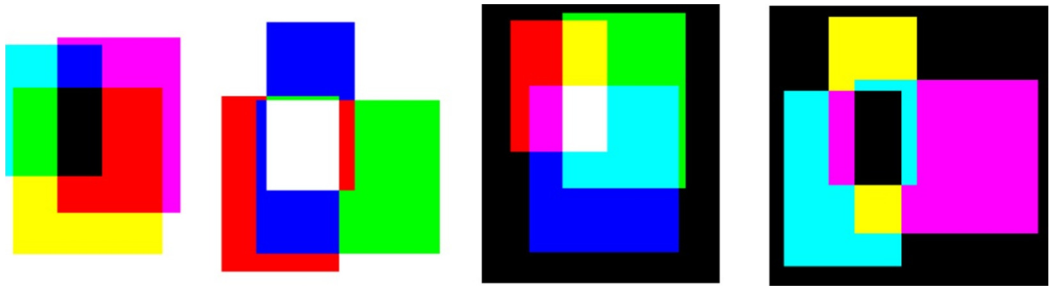

Fig. 34. Illustration of blending modes: difference.

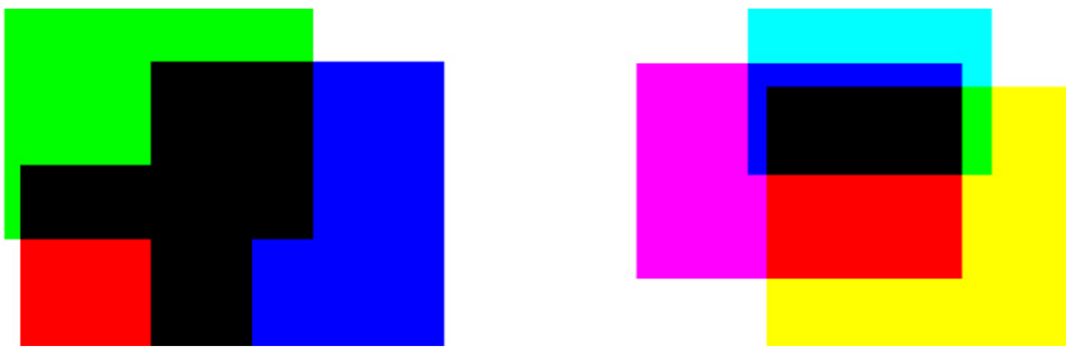

Fig. 35. Illustration of blending modes: subtract.

Below I describe further each piece and provide the specifications of the loops used to construct them.

V-Hold

This piece (fig. 36) was inspired by the vertical synchronization on CRT televisions. The image is composed of 15 layers, five for each RGB color channel. The first five layers are blue, the next five are green and the last five are red. The alpha channel of the layers is set to 50% transparency and the color mode is set to "screen", so that when the image is on a black background, the colors blend in additive mode. The image is animated to move downward at 1pixel per frame, in a continuous cycle. The duration of the first animation loop is 1080 frames. For each of the next loops, one frame is added to the duration of the immediately previous loop, so that the duration of the second loop will be 1081 frames, up to 1094 frames. The added frame is a repetition of the last frame – the result is that the image will stay still for the number of repeated frames in all loops except for the first one, which is continuous.

Because of the differences in duration of the loops, as the piece progresses, the layers gradually go in and out of register, creating 125 colors during the process and various image patterns. Due to the repeated frames in the end of each loop there are moments when parts of the original image are restored, this way always referencing the first loop.

In the first iterations of the cycle the edges of the figure look out of focus due to the proximity of the edges of the overlapped color layers in 50% transparency, after which a gradient is created, and then, various combinations of the layers.

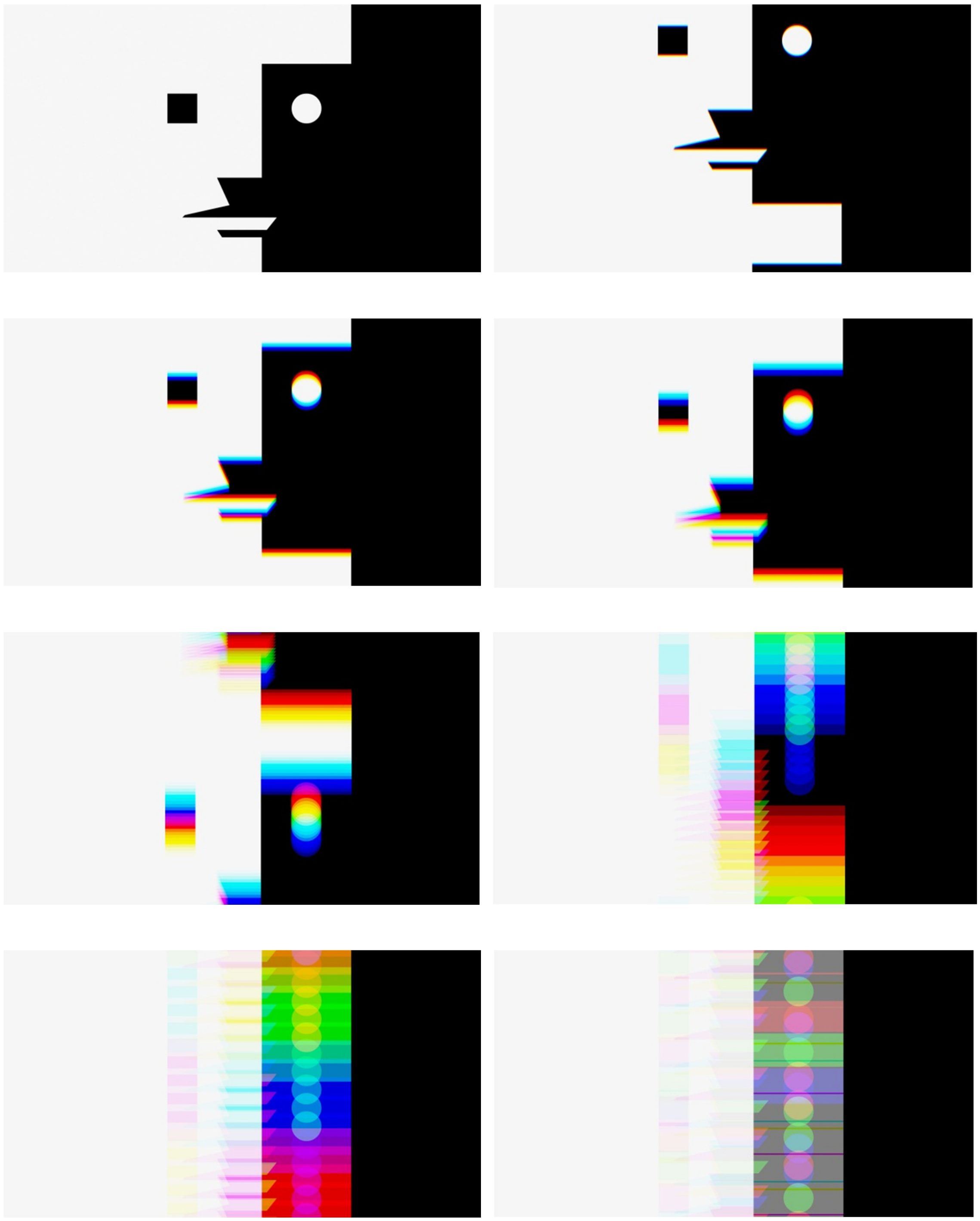

Fig. 36. ***V-Hold.***

H-Hold

This piece (fig. 37) was inspired by the horizontal synchronization on CRT televisions. The image is composed of 216 horizontal lines, each formed by three animation loops, one for each RGB color, for a total of 648 loops. The first red channel horizontal line is continuous and has 1920 frames. New frames were added to the end of the next red channels horizontal lines, extending the duration up to 2135 frames. The added frames are a repetition of the immediately previous one, so that the movement seems to stop and the animation loops gradually desynchronize. The duration for the green channel horizontal lines begins at 1921 (1920 of motion and 1 repetition of the last frame) and progresses to 2136 frames. The duration for the blue channel horizontal lines begins at 1922 (1920 of motion and 2 repetitions of the last frame) and progresses to 2137 frames.

The background is black, the color blend mode is additive, and the white areas are the result of the combination of the three color channels. Due to the differences in the duration of the loops, as the piece progresses, the layers gradually go in and out of register, creating 8 colors during the process as well as various image patterns. Due to the repeated frames in the end of each loop there are moments when parts of the original image are restored, in this way always referencing the first iteration.

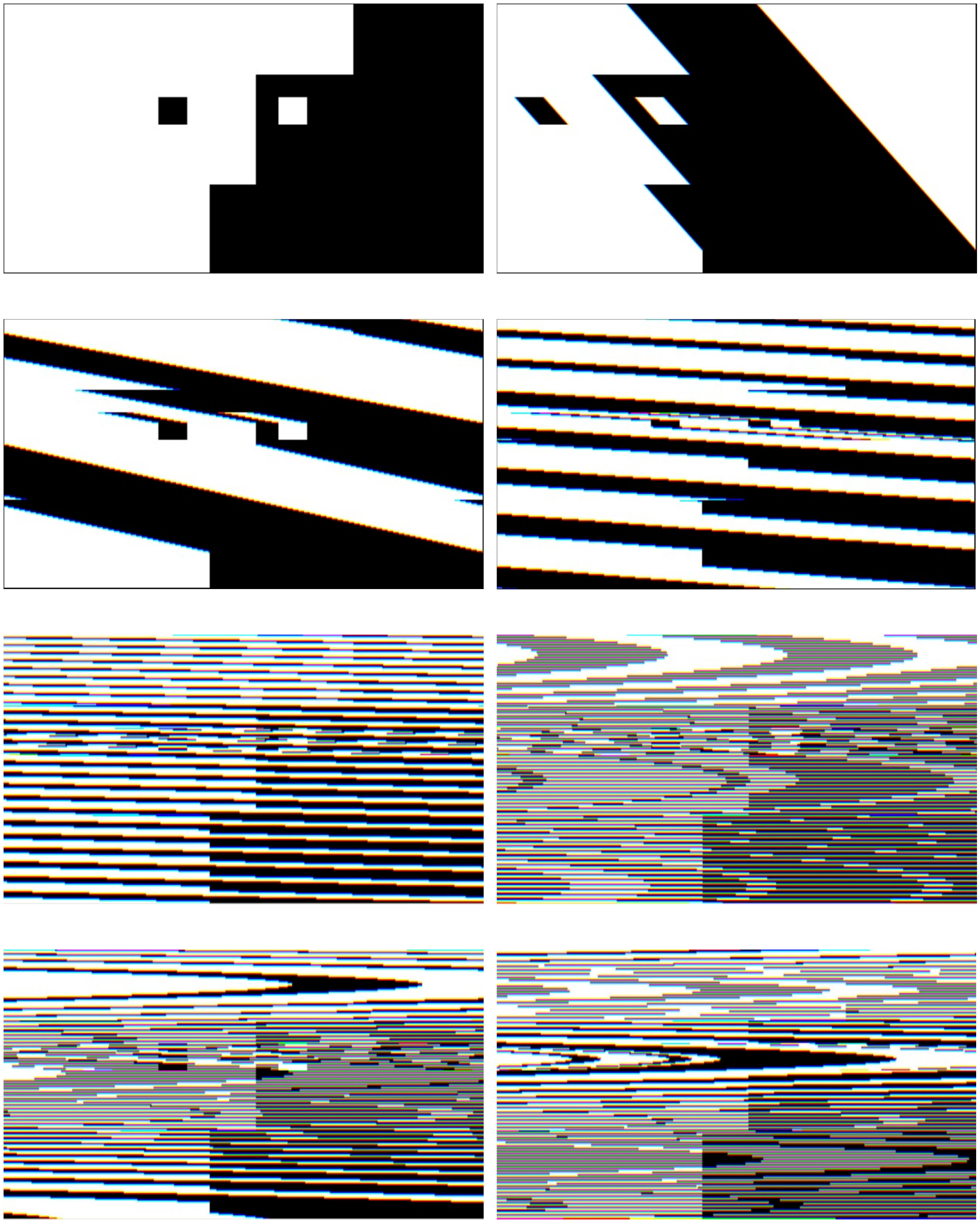

Fig. 37. ***H-Hold.***

Convergence

In CRT screens, a picture is said to be in convergence when RGB channels overlap. *Convergence* (fig. 38) uses motion loops in which, as the image of the face moves from screen right to screen left, the colors go out of convergence, revealing colors and their combinations.

The image is formed by seven elements layered on a white background: the outline of the face and eye, the shape of the face, and two black blocks that consist of the negative image of the face. The outline is formed by three layers of colors in “difference” blending mode. The shape of the face is formed by three layers of colors in “multiply” mode.

Each layer moves on a loop that has different numbers of frames. The elements move from right to left at a rate of 1 pixel per frame. The black, negative image moves in a loop with n frames (n = 1920). The outline is formed by three loops (R, G, B), respectively with $n+1$, $n+2$ and $n+3$ frames. The head is formed by three loops (R, G, B), with $n+4$, $n+5$ and $n+6$ frames. The duration therefore is approximately 6.33×10^{19} frames, or approximately 8.36×10^{10} years, which is in the same order of magnitude as the estimated age of the universe.

When the layers combine in different blending modes, the resulting colors vary. If three lines (R, G, B) in difference mode overlap, the result is transparency, and therefore the outline appears to be originally white, revealing the white background. When any of the layers of the face overlaps the black blocks, the resulting color is still black, so the image of the face does not appear to bleed into the "black background". Due to the outline being in difference mode, when its layers overlap the black blocks, it appears as cyan, magenta and yellow. If a layer of a given color in difference mode overlaps a layer with the same color in multiply mode, the result is black. If the colors are different, the result is the complement of the base color.

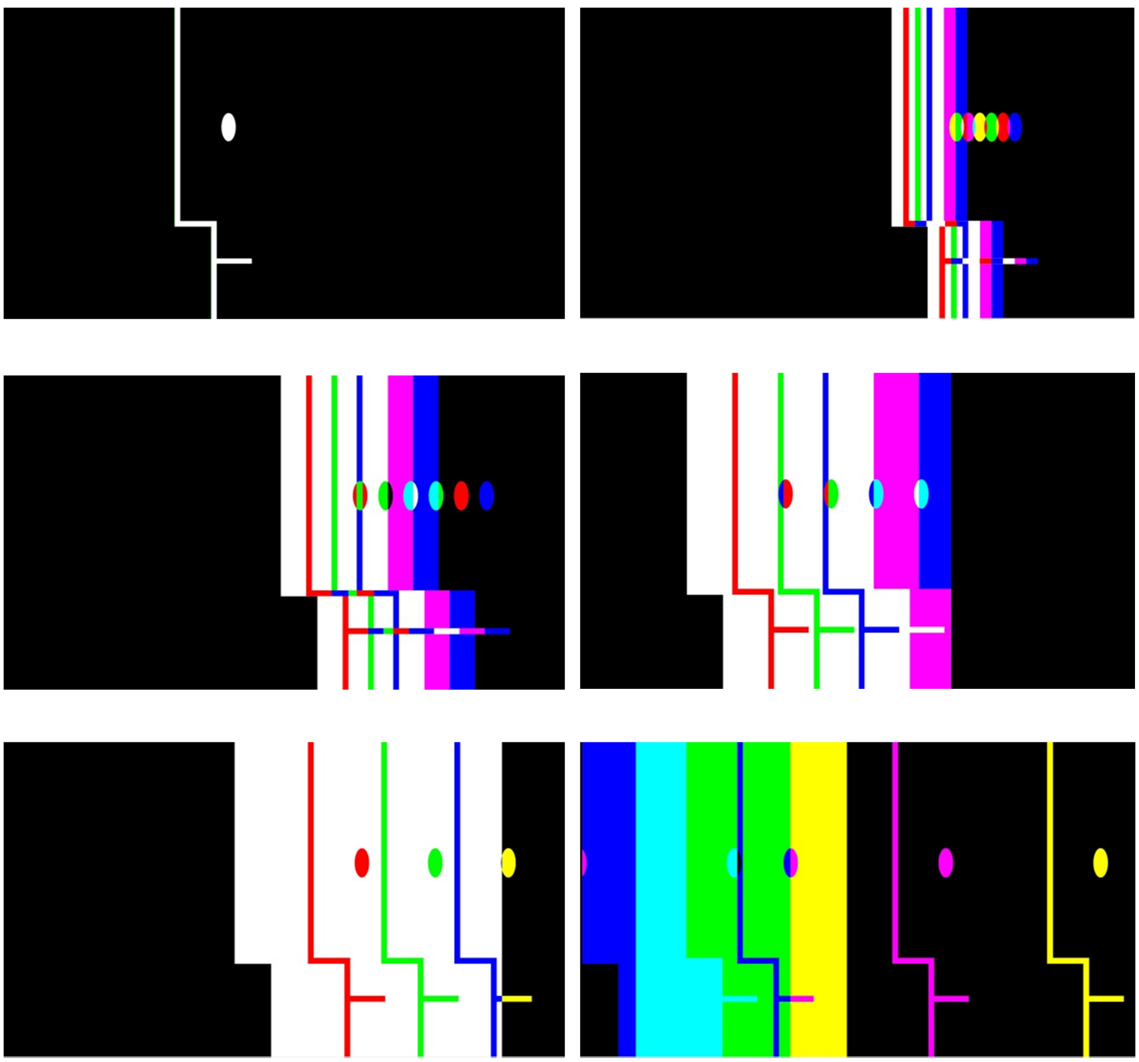

Fig. 38. ***Convergence.***

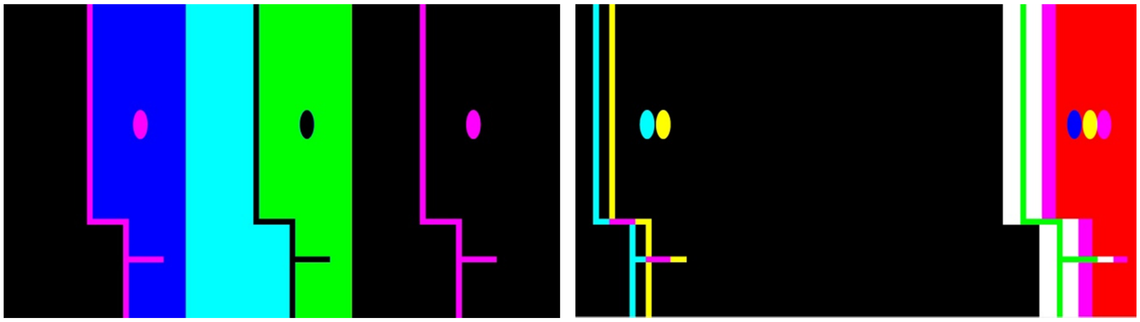

Fig. 38. ***Convergence*** **(continued).**

Scan Lines

This piece (fig. 39) references the scan lines of televisions. Color variation is produced by the interaction of lines fading out and in. The image is composed of a set of horizontal lines: 36 blue, 37 green and 37 red. These lines are 30 pixels high, but partially overlapped – so the height of the first green line is 20 pixels and the last one is 10 pixels; the first red line is 10 pixels and the last one is 20 pixels. Each of these lines cycles from zero to 100% transparency and back to zero. The fading (out+in) cycle of the first red line is 512 frames long, with a midpoint (complete transparency) at frame 256. I have used 256 because this is the number of possible values for each channel in RGB color model, so that it is possible to generate 16,777,216 colors. The last frame is repeated once in the second red line, producing a duration of 513 frames; one frame is added progressively to each of the subsequent lines. The same rule applies to the green lines and the blue lines: the cycle of the first green line has 513 frames and the first blue line, 514.

The lines slowly go out of synchrony, generating variation of color. Initially, the image is black and white, then proceeding to gray, sepia, and saturated colors; as the piece progresses, combinations of different color values are present.

Due to the phasing effect, the viewer can perceive downward and upward vertical movement of the lines, although the lines do not move – they only fade out and in.

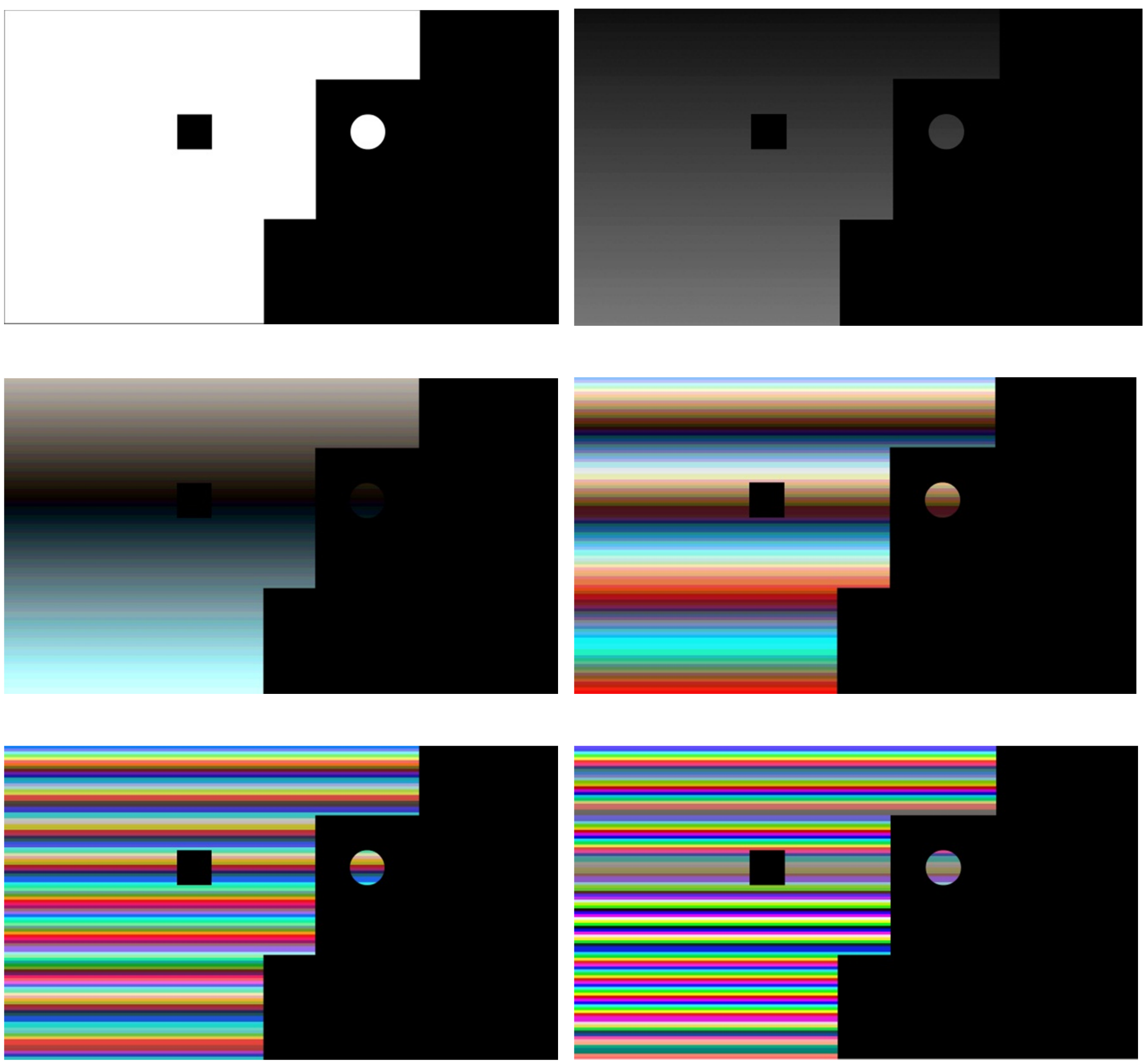

Fig. 39. ***Scan Lines.***

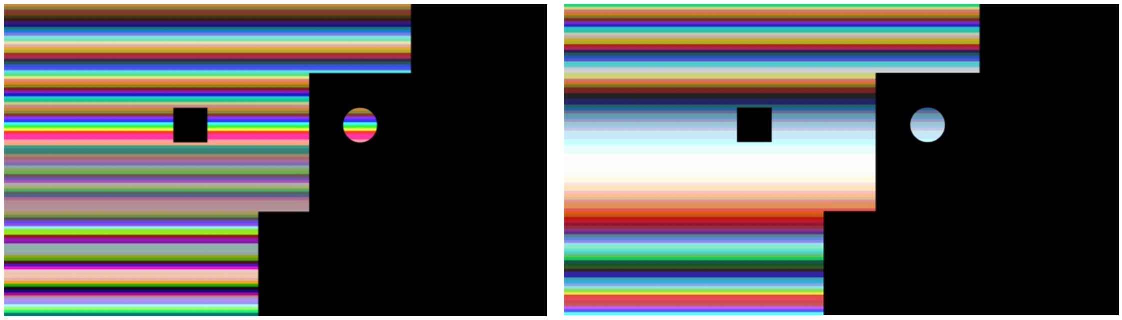

Fig. 39. ***Scan Lines*** **(continued).**

Ghosts

Ghosts (fig. 40) combines motion and color/transparency loops in which the image layers move from different directions.

The image is formed by 9 layers in 3 sets. The first set is red, blue and green, in additive ("screen") mode. When they overlap, they produce white. The red layer moves downward; the green moves upward, and the blue moves from right to left of the screen. The other two sets are cyan, magenta and yellow, in subtractive blending mode. When three layers of cyan, magenta and yellow combine in subtractive mode, they produce black. In the second set the cyan layer moves diagonally from the upper right corner to the left lower corner of the screen; the magenta moves from the lower right corner to the upper left corner, and the yellow moves from left to right. In the third set, the magenta layer moves from the upper left corner to the lower right corner; the yellow moves from the bottom left corner to upper right corner, and the cyan, differently from the other layers, only fades out and in. All images are set to a fading out/in cycle, so that they reach complete transparency on frame 256 and return to opacity in frame 512.

Considering the color/transparency loops, the animation with no motion is 512 frames long. One frame is added progressively (a repetition of the previous frame) to each animation, counting clockwise, reaching 520 frames. For the motion loops, the images move at 0.5 pixel per frame, and one frame is added progressively to each animation, counting clockwise, except for the one with no movement.

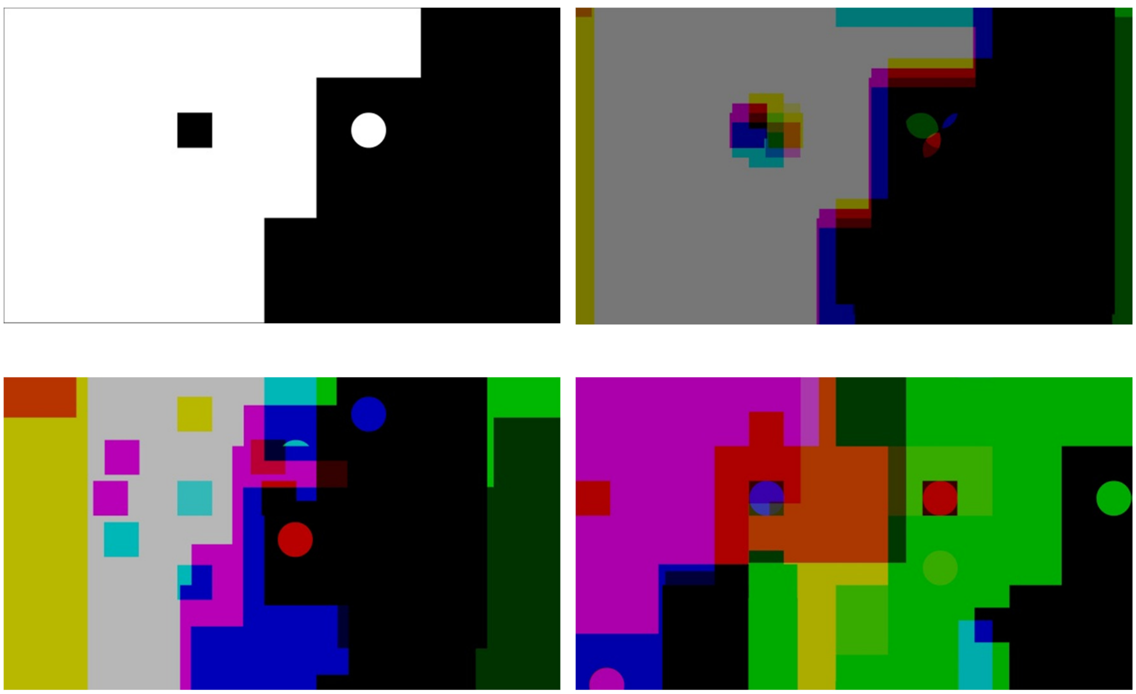

Fig. 40. ***Ghosts.***

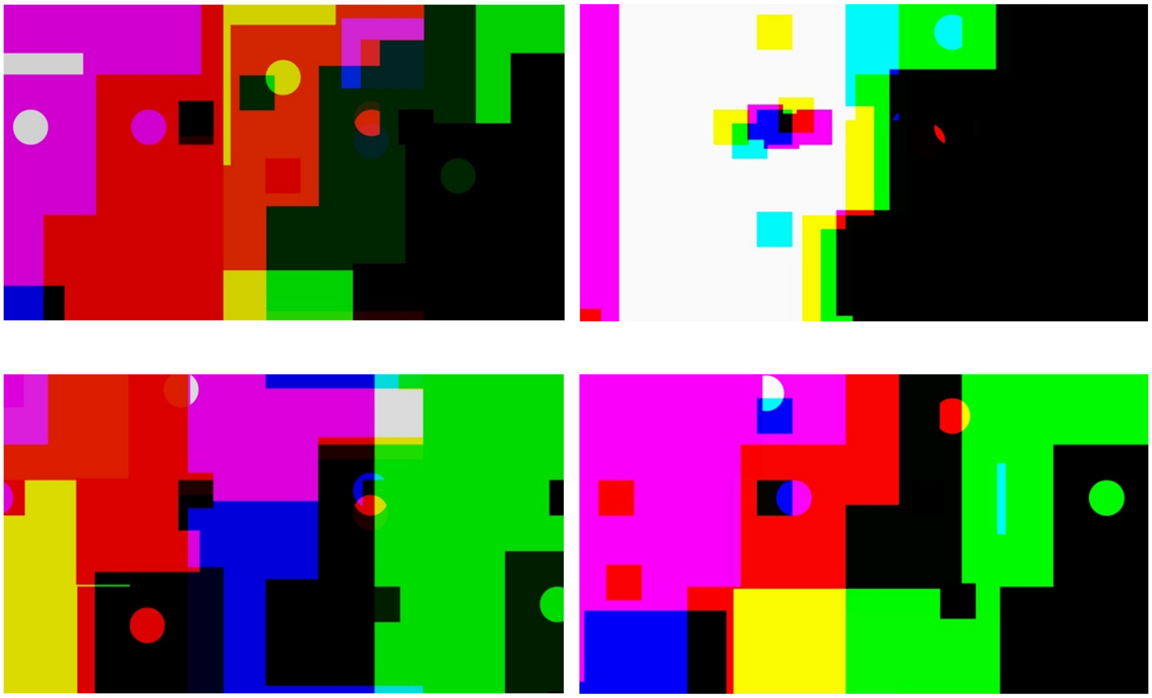

Fig. 40. *Ghosts* (continued).

Bitmap

Bitmap (fig. 41) consists of flicker loops, with blank frames interspersed among the image frames in the loop. In this image, two groups of layers are defined: the first group is formed by three layers (cyan, magenta and yellow) in subtractive mode, so their overlap forms black. This is the black area of the face. The second group is formed by three layers (red, blue and green) in difference mode, so that when they are overlapped the result is transparency. This is the white area of the face.

During the loop, there are five positions the image can assume. Using the center of the initial face's square "eye" as a reference point, in the other four positions the image is displaced so that each time a different vertex of the face's square eye is at the center of the initial square. Every time the image 'disappears' due to the flicker, it reappears in a different quadrant alignment. The sequence of movement among the quadrants is different for each of the six loops, so that their colors become apparent when they move out of alignment.

The flicker is set up so that there is an increasing number of blank frames, varying from 1 to 5, following the equivalent number of frames with an image. For example, one frame with image, one blank, two frames with image, two blank, and so on. There are six layers, and each begins with a different number of image/blank frames (1, 2, 3, 4 or 5). The first layer has a duration of 30 frames; the subsequent layers have increasing numbers of blank frames at the end, totaling 31 to 35 frames. Therefore, the phasing cycle is 19,477,920 frames long, or approximately 255 hours and 30 minutes.

Movement is perceived due to sequences of elements of the same color appearing at different positions of the screen. Depending on the frequency of the flickering, colors that are not present in the piece can be perceived.

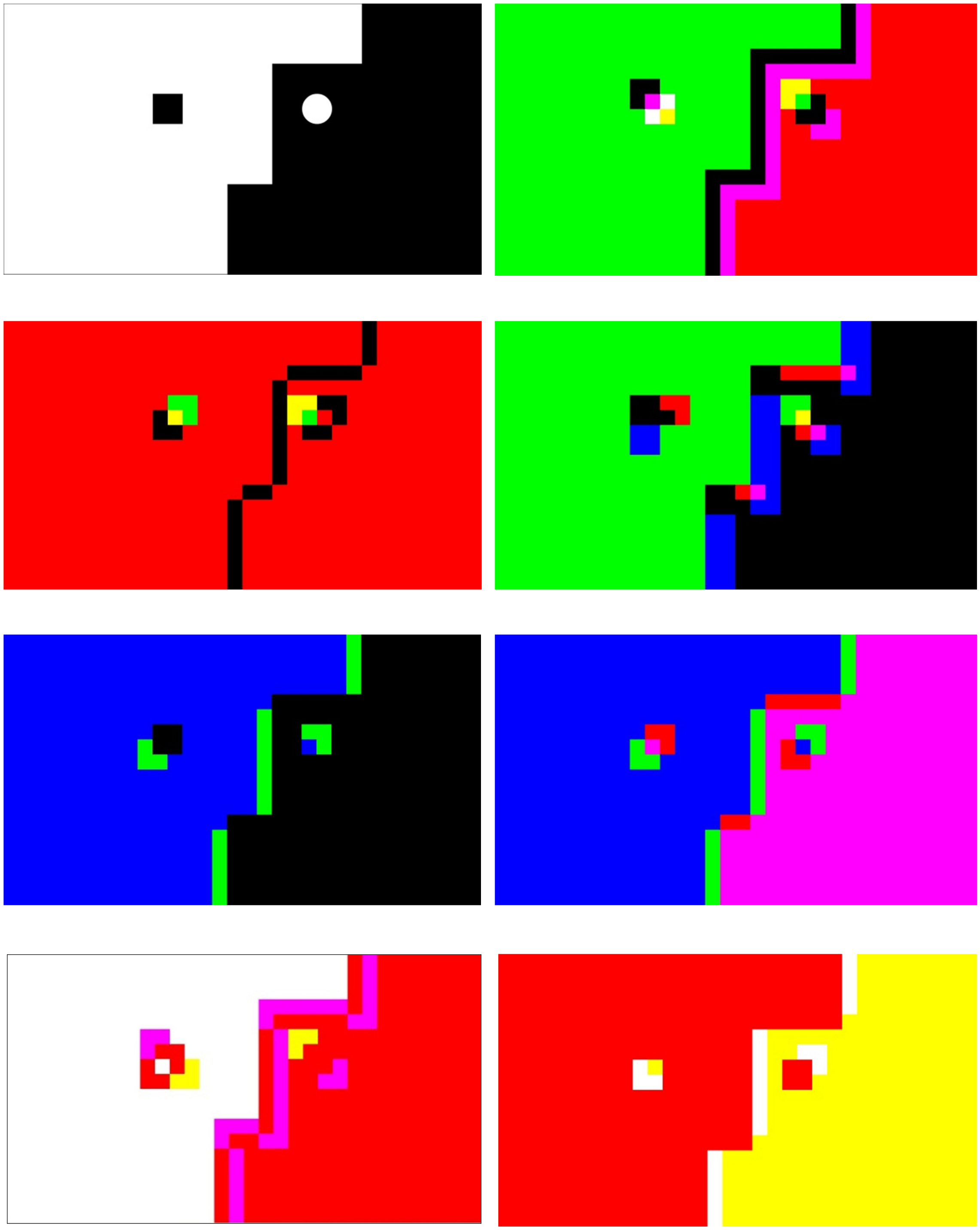

Fig. 41. ***Bitmap*****.**

Color Bars

In this animation (fig. 42), there are four face images, formed by three layers each, in subtractive color blending mode. The layers have different colors (cyan, magenta, yellow), so that in the initial image, when all layers overlap, the image is black and white. Flickering occurs due to blank frames added to each of the loops; therefore, when one or more of the layers has temporarily disappeared, the other colors become apparent. The face images are slightly out of horizontal alignment, becoming more or less evident as they flicker.

The flicker is set up so that there is an increasing number of blank frames, varying from 1 to 5, following the equivalent number of frames with an image. For example, one frame with image, one blank, two frames with image, two blank, and so on. There are sixteen layers, and each begins with a different number of image/blank frames (1, 2, 3, 4, 5 and 6). The first layer's duration is 42 frames; the subsequent layers have increasing numbers of blank frames at the end, totaling 43 to 57 frames. Therefore, the phasing cycle is approximately 6.02×10^{16} frames long, or approximately 79,538,728 years.

Horizontal movement is perceived due to sequences of face images of the same color appearing at different positions of the screen. Depending on the frequency of the flickering, colors that are not present in the piece can be perceived.

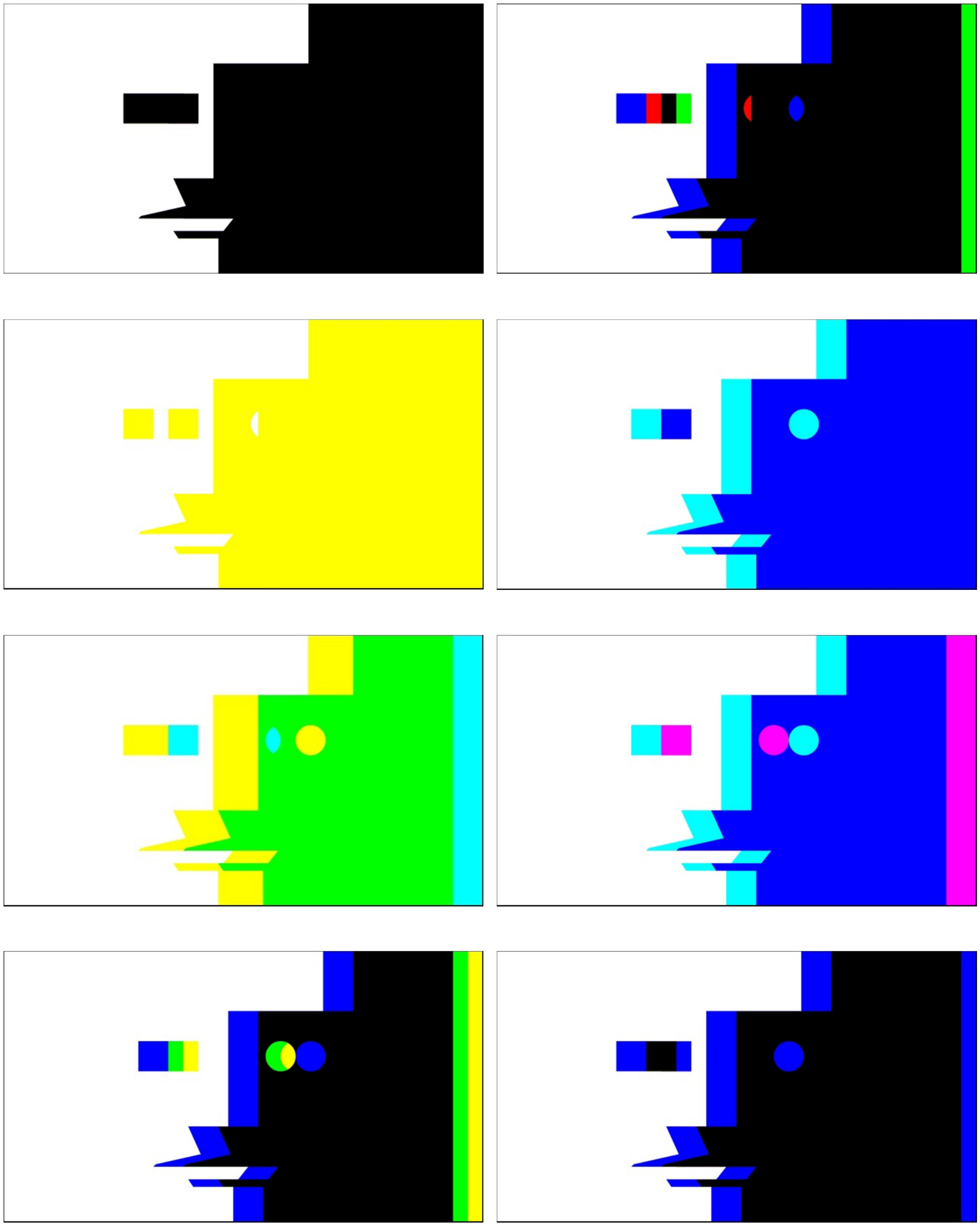

Fig. 42. ***Color Bars*.**

Tune In

Tune in (fig. 43) uses shape transformation and transparency/color loops. There are six partially overlapping, evenly distributed face figures. The black part of each of the six figures is formed by three layers (cyan, magenta and yellow) in subtractive color model. The circular, initially white eye is formed by another three RGB layers in additive color model.

In the shape transformation, straight vertical lines from the black figure become curved, and the circular eye becomes a square. Each of the RGB and cyan, magenta and yellow layers changes its shape in loops with slightly different durations. For the face layers, the duration of the loop is 400 frames for cyan, 401 for magenta and 402 frames for yellow the same for all the face figures. Being that the lines are straight in frames 1, 200 and 400; they reach the maximum curvature on frame 100 and 300. For the eye transformation, the cyan loop is 200 frames long; the magenta, 201, and the yellow, 202, the same for all fix eye figures. The shape changes gradually from a circle (frames 0, 200) to a square (frame 100). The images alternate fading out/in and in/out cycles, so that they reach complete transparency/opacity on frame 256 and return to opacity/transparency in frame 512. One frame (a repetition of the previous frame) is added progressively to each of subsequent image from right to left. The fade cycle for red images ranges from 512 to 518 frames, the fade cycle for green images ranges from 513 to 519 frames, and the fade cycle for blue images ranges from 514 to 520 frames. As the loops desynchronize it generates color and shape variation. Initially, the image is black and white, then proceeding to gray, sepia, and saturated colors; as the piece progresses, combinations of different color values are present.

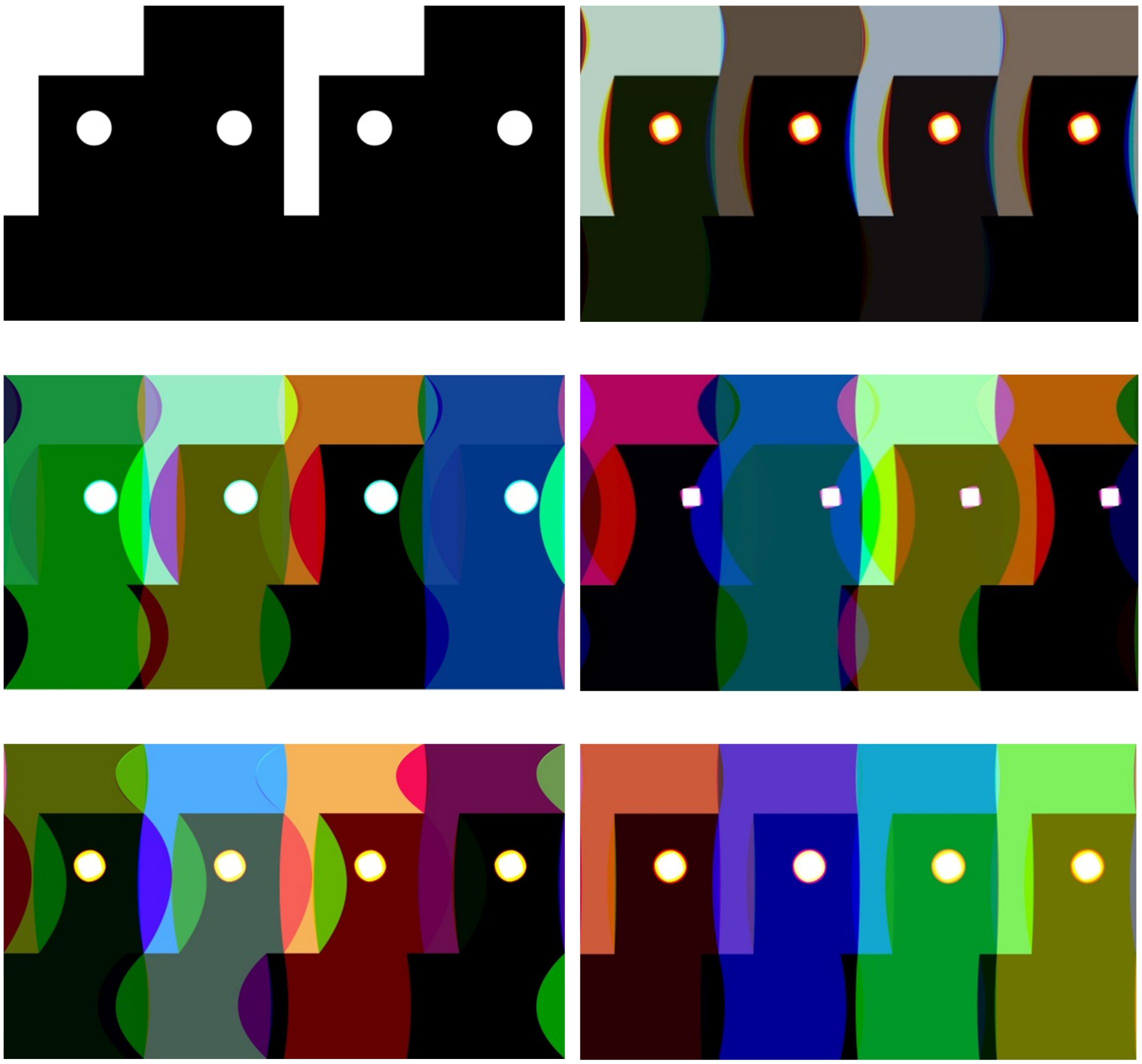

Fig. 43. ***Tune In.***

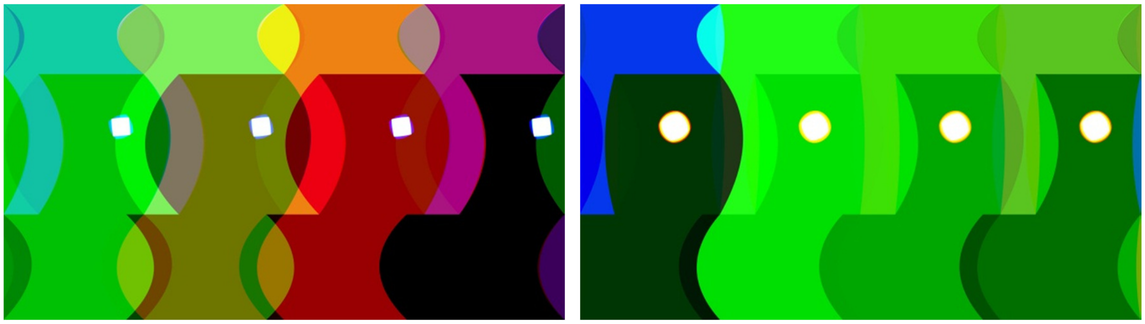

Fig. 43. ***Tune In*** **(continued).**

FUTURE WORK

Future iterations of this work could involve further explorations of digital and analog video distortion using magnets and electromagnets on CRT televisions and monitors, single-channel and multi-channel projections, adaptation for live performance, production of Flash and animated GIFs for the Internet, and production of fixed media DVDs.

An improvement on this work would be to run the animation based on the computer clock and to set a starting date and time to each piece, so every time the file is accessed, the animation would start at a point corresponding to the date and time. Thus it would function as if uninterrupted.

Phasing loops can be used in different contexts in visualization, from screen-saver applications to introducing variation in video-game levels. Other possibilities with research and experimentation could involve 3D graphics or live action to create scenes in which elements and characters in the scene would appear in different loops. Therefore in each iteration the relationship between the characters would vary.

CONCLUSION

In this thesis I have described the elements I incorporated in a generative cinema installation using phasing loops. These animations are based on the particular properties and elements of a variety of video and film display technologies, allowing the attentive viewer to recognize the (re)production of effects typical of these media through observing the loops. I have also described earlier work that explored these elements. This thesis serves as a reference for the documentation of the development process and discussion of the final artwork.

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